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COMMERCIAL MINERALS

OF

CALIFORNIA

BULLETIN NO. 124

Issued by the
California State Division of Mines
Ferry Building, San Francisco

1942

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

DIVISION OF MINES
Walter W. Bradley, State Mineralogist

San Francisco | BULLETIN 124 | October 15, 1942

COMMERCIAL MINERALS OF CALIFORNIA

By
George L. Gary
Mineral Technologist

1942

INTRODUCTION

In April 1941 the first papers of this series were mimeographed for distribution to the citizens of the State of California who were interested in developing our mineral resources. They were originally run off in lots of five to fifteen hundred, depending upon the importance of the subject. Several of the papers have been rerun ten to fifteen times.

These papers are distributed through the main office of the State Division of Mines, Ferry Building, San Francisco, and through our regional offices at Los Angeles, Sacramento and Redding, and are also available at many of the public libraries and universities of the western states. In many cases they were reprinted, with our permission, by technical journals, magazines and newspapers.

As there has been a demand for a complete series it was decided to issue all of these papers, some fifty in number, as a loose-leaf bulletin. The bulletin is so arranged that it may be revised and expanded as marketing conditions change, and it is the intention of the Division of Mines, as these changes occur, to supplement this bulletin with additional up to the minute information on the properties, occurrence, preparation, uses, tests, markets, and possible buyers, with a bibliography concerning these commercial minerals.

These revised papers will be available to anyone upon receipt of postage. Announcements will be made of all new material in the Divisions "Monthly Commercial Mineral Notes."

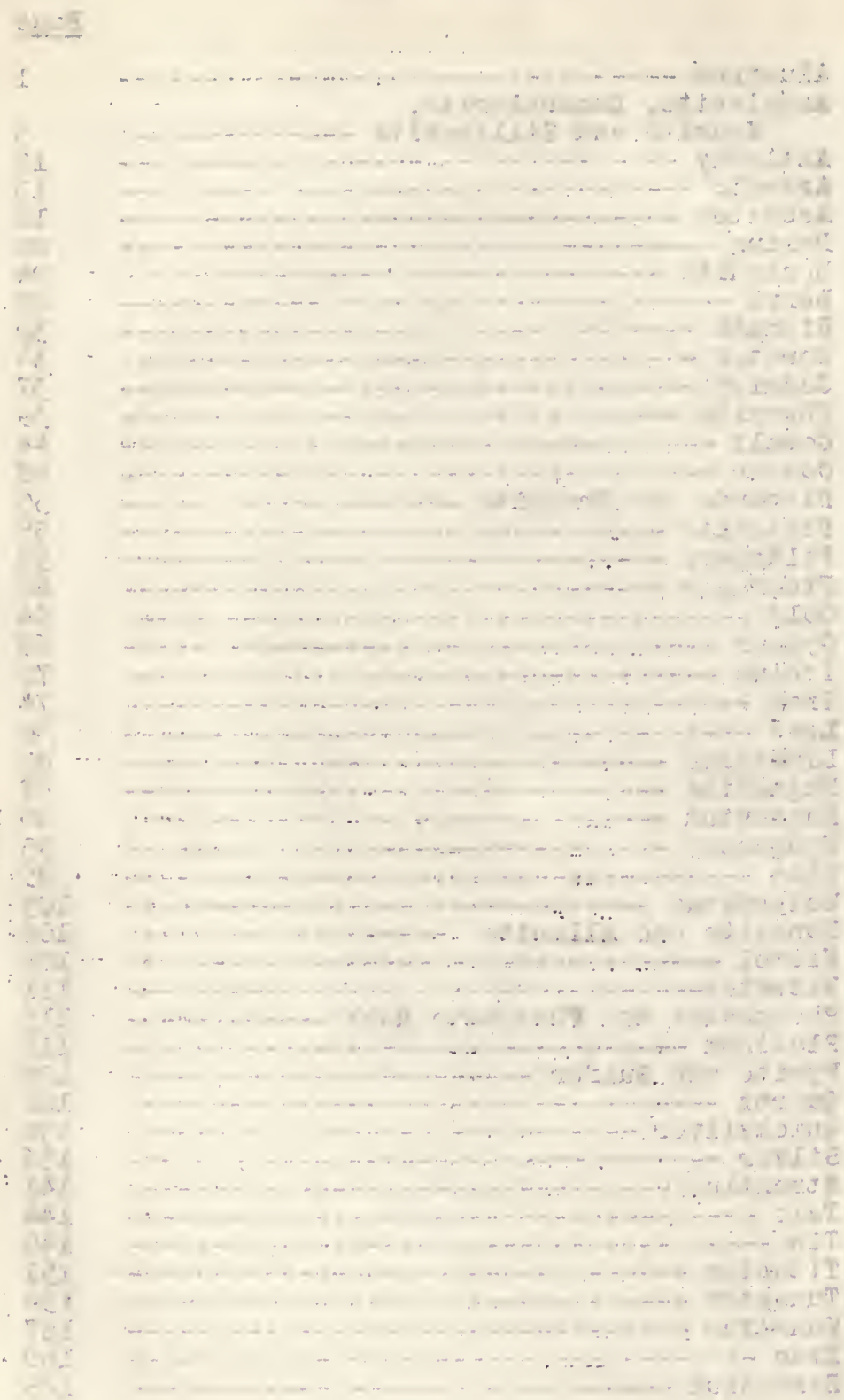
The so-called strategic and critical minerals are included in this bulletin, but all of the minerals listed in the table of contents are important and will play their part in World War II, as it is becoming more and more evident to our people that the mining industry is the backbone of our country's resources.

-----oOo-----

The perforations will fit any standard size binders which are available in varying grades and prices at any stationery store including the "five and ten".

TABLE OF CONTENTS

	Page
Aluminum	1
Andalusite, Dumortierite, Kyanite and Sillimanite	5
Antimony	10
Arsenic	13
Asbestos	16
Barium	20
Bentonite	24
Beryl	28
Bismuth	32
Borates	34
Cadmium	37
Chromite	39
Cobalt	44
Copper	46
Diamonds and Graphite	50
Diatomite	55
Feldspars	58
Fluorspar	62
Gold	64
Gypsum	69
Iodine	72
Iron	74
Lead	80
Limestone	83
Magnesite	87
Magnesium	90
Manganese	95
Mica	99
Molybdenum	103
Monazite and Allanite	106
Nickel	108
Nitrates	111
Phosphates and Phosphate Rock	115
Platinum	118
Pyrite and Sulfur	122
Quartz	126
Quicksilver	132
Silver	136
Strontium	141
Talc	144
Tin	148
Titanium	151
Tungsten	154
Vanadium	157
Zinc	160
Zirconium	163



State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

MAY - 1941

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

ALUMINUM

By
George L. Gary, Mineral Technologist

PROPERTIES - The principal commercial ore of aluminum is bauxite, a mixture of hydrous aluminum oxides of indefinite composition. Some bauxites approach closely the composition of gibbsite, $Al(OH)_3$, but most are a mixture, and usually contain iron. As a result, bauxite has been discredited as a mineral species and in a rigid classification should be used only as a rock name, but the name has been retained here since it has become so firmly fixed as the name of the important commercial substance. The principal constituents of the rock bauxite are gibbsite, $Al(OH)_3$, boehmite, $Al(OH)_3$, and diaspore, $AlO(OH)$, any one of which may be dominant. Cliachite, $Al(OH)_3$, is the name proposed for the very fine-grained amorphous constituent of bauxite. Cryolite, Na_3AlF_6, imported from Greenland, has been used as an ore of aluminum and also as a flux in the electrolytic process by which most of the metal is obtained. Aluminum is the most abundant of the metals, for it is an essential constituent of most of the rock-forming silicates and of clays derived from their alteration. However, the enormous amounts of aluminum contained in the various silicates are not yet available because of the difficulty and expense of extraction, and only the rock, bauxite, a mixture of hydrous aluminum oxides, is at present an important ore. Bauxite is found in pisolitic, or round concretionary grains; also massive, earthy and clay-like. The luster is dull to earthy. The color and streak is white, gray, yellow and red. The hardness is 1-3; the gravity is 2-2.55.

OCCURRENCE - Bauxite is of secondary origin, commonly produced under subtropical to tropical climatic conditions by the prolonged weathering of aluminum bearing rocks. It also may be derived from the weathering of clay-bearing limestones. It has apparently originated as a colloidal precipitate. It may occur in place as a direct derivative of the original rock, or it may have been transported and deposited in a sedimentary formation. In the tropics deposits known as laterites, consisting largely of hydrous aluminum and ferricoxides, are found in the residual soils. These vary widely in composition and purity but may become valuable as sources of aluminum and iron. Bauxite occurs over a large area in the south of France, an important district being at Baux (originally Beaux), from which locality it derived its name. Large quantities are produced in Dutch Guiana and British Guiana and shipped to the United States. In the United States

ALUMINUM (Continued)

the chief deposits are found in Georgia, Alabama, and Arkansas where bauxite was formed by the alteration of a nepheline-syenite. Pisolitic bauxite has been found in one locality in Riverside County, California, and diaspore occurs in compact masses with andalusite in one locality in Mono County, California. Transparent crystals of diaspore in chlorite schist have been found by the writer in one locality in Calaveras County, California.

PREPARATION - The usual process at present by which aluminum is extracted from the bauxite ores is briefly as follows: The ore is heated to low redness with sodium carbonate, forming sodium aluminate. This compound is leached out by water, and by passing CO_2 gas into the solution the aluminum is precipitated as the hydroxide. On being heated the hydroxide is converted into the oxide of the metal. The pure metal is prepared from this oxide by an electrolytic process which takes place in a bath of fused cryolite, or an artificial sodium-aluminum fluoride. The tank in which the reaction takes place is lined with carbon and forms the cathode, graphite rods suspended in the bath serving as the anode. The metal collects in the bottom of the tank. About 4 tons of bauxite are needed to make 2 tons of the oxide, which in turn makes about 1 ton of aluminum.

USES - Because of its great strength and low density, aluminum has been adapted to many uses. Sheets, tubes, and castings of aluminum are used wherever a light-weight metal is desired, as in the manufacture of automobiles, airplanes, railway cars, and machinery. It is used extensively in cooking utensils and household appliances and furniture. Aluminum is a good electrical conductor and to some extent is replacing copper in power transmission lines. Numerous aluminum alloys are in common use. Duraluminum, 96 percent aluminum, 3 percent copper, and 1 percent magnesium, is the trade name of the most important. It has only one-third the weight of steel and yet possesses most of its desirable properties. Aluminum bronze contains 10 percent aluminum, 90 percent copper. Aluminum is also alloyed with zinc, nickel, silicon, silver and tin. Other uses of aluminum are in paint, aluminum foil, and as a constituent of numerous salts.

TESTS - Infusible aluminum minerals, when moistened with cobalt nitrate and intensely heated before the blowpipe, assume a blue color. The mineral should be powdered and heated either on charcoal or on the loop of a platinum wire. Ammonia, when added in excess to an acid solution containing aluminum precipitates aluminum hydroxide. The precipitate is flocculent and colorless or white. It is precipitated under the same conditions as ferric hydroxide and since the latter has a dark color a small amount of aluminum hydroxide might be overlooked in a mixture of the two. To make a further test under these conditions, filter off the precipitate and treat it with a hot solution of sodium hydroxide, which will dissolve any aluminum hydroxide present but will not affect the ferric hydroxide. Filter, to the filtrate add hydrochloric acid in slight excess, and then make alkaline with ammonia hydroxide again. This will precipitate as pure aluminum hydroxide any aluminum that may be present.

MARKETS - Aluminum per lb., delivered, commercial and mill ingot, 99 percent, 15¢. Bauxite per long ton: Domestic ore, chemical, crushed and dried, 55 to 58 percent Al_2O_3, 1.5 to 2.5 percent Fe_2O_3, $7.50 @ $8.50, f.o.b. Alabama and Arkansas mines. Other grades 56 to 59 percent Al_2O_3, 5 to 8 percent SiO_2, $7.50 @ 8.50, f.o.b. Arkansas mines. Pulverized and dried, 56 to 59 percent Al_2O_3, 8 to 12 percent SiO_2, $14.00 @ $16.00 f.o.b. Arkansas mines; abrasive grade, crushed and calcined, 80 to 84 percent Al_2O_3, $16.00. f.o.b. Arkansas mines. Crude (not dried) 50 to 52 percent, $5.00 f.o.b. Arkansas mines. (Quotations April 30, 1942.)

POSSIBLE BUYERS

Aluminum Ore Co., subsidiary of Aluminum Co. of America, Gulf Building, Pittsburg, Pa.
American Cyanamid & Chemical Corporation, 30 Rockerfeller Plaza, New York, N. Y.
E. I. du Pont de Nemours & Co., Incorporated, 1007 Market Street, Wilmington, Del.
General Chemical Co., 40 Rector Street, New York, N. Y.
Gulf Oil Corporation, Gulf Building, Pittsburg, Pa.
Hercules Powder Co., Wilmington, Del.
Mineral Products Corporation, Marysvale, Utah.
National Aluminate Corporation, 6216 West 66th Place, Chicago, Ill.
Stauffer Chemical Co., 624 California Street, San Francisco, Calif.
The Carborundum Co., Niagara Falls, N. Y.

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Herbert A. Franke and M. E. Trought, Bauxite and Aluminum: Minerals Yearbook, 1940. U. S. Bur. of Mines, pp 637-658.
E. C. Harder. Bauxite. Industrial Minerals and Rocks, 1937: The American Institute of Mining and Metallurgical Engineers, pp. 111-128.
C. L. Mantell. Aluminum and Bauxite: The Mineral Industry During 1939: McGraw-Hill Book Co., New York and London, 1940, pp. 7-27.
Adolf Pabst. Minerals of California: California State Division of Mines. Bulletin No. 113 (1938).
G. A. Roush. Strategic Mineral Supplies. McGraw-Hill Book Co., New York and London, 1939, pp.200-237.
J. R. Thoenen and Ernest F. Burchard - Bauxite Resources of the United States. U. S. B. M. R. I. No. 3598, 1941.
J. R. Thoenen - Alunite Resources of the United States. U.S.B.M.R.I. No. 3561 - 1941.

NOTES

1. Specimens of aluminum ores may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Alunite, a basic potassium aluminum sulfate, $KAl_3(OH)_6(SO_4)_2$, is used in the production of alum. Recently at Marysvale, Utah, alunite has been mined and treated in such a way as to recover aluminum from the mineral.

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State of California
Department of natural resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

APRIL - 1942

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

ANDALUSITE, DUMORTIERITE, KYANITE, AND SILLIMANITE

By
George L. Gary, Mineral Technologist

PROPERTIES - Andalusite, kyanite, and sillimanite are aluminum silicates having the same chemical formula, Al_2SiO_5, and containing 63.2 percent aluminum with 36.8 percent silica.

Andalusite crystallizes in the orthorhombic system and occurs in rough attached or embedded crystals, in columnar masses and rounded pebbles. Vitreous luster. Cleavage is parallel to the length of the crystal. The color is usually gray but may be whitish, rose red, flesh red, violet, reddish brown, or olive green. The variety known as chiastolite has symmetrically arranged black and white areas of carbonaceous matter in the form of a cross. Hardness 7½. Specific gravity 3.18.

Kyanite (triclinic crystal system) occurs characteristically as bladed crystals although it may be coarsely bladed columnar, grading into subfibrous. Cleavage perfect parallel to the length of the crystal. Imperfect cleavage may also be observed parallel to the length of the crystal but at an angle to the more prominent cleavage. Luster vitreous to pearly. Color blue, white, gray, green, black. May be blue along the center of the crystal with white margins. Hardness is 4½ parallel to the length of the crystal and 7 at right angles to the length. Specific gravity 3.60.

Sillimanite (orthorhombic crystal system) is usually found as long slender crystals not distinctly terminated, or in close parallel groups, passing into fibrous and columnar massive forms. Cleavage parallel to the length of the crystal. Vitreous luster approaching subadamantine. Color brown, grayish brown, grayish, white, grayish green, and pale olive green. Hardness 6 to 7. Specific gravity 3.23.

Dumortierite, $8Al_2O_3.B_2O_3.6SiO_2.H_2O$. (basic aluminum borosilicate) usually occurs in fibrous to columnar aggregates. Crystallizes in the orthorhombic system. Cleavage parallel to the length of the crystal. Luster vitreous. Color bright smalt blue to greenish blue. Hardness 7. Specific gravity 3.26 to 3.36.

OCCURRENCE - In California, andalusite, kyanite, and sillimanite occur principally in schist and gneiss although they are common in quartz veins or quarzitic masses. They are probably the products of high temperature metamorphism of aluminous sediments or aluminous volcanic material.

Andalusite and chiastolite are found in Fresno, Madera, Mariposa, Mono, Nevada, Riverside, San Diego, and Tulare counties. In addition, chiastolite has been reported from Kern and Sacramento counties.

The andalusite deposit of Champion Sillimanite, Inc., is located on the north side of Dry Creek Canyon on the northwest slope of the White Mountains, Mono County, and is the largest in the United States. The mineral occurs in irregular segregations in a lenticular quartz mass and is associated with sericite, pyrophyllite, muscovite, corumdum etc.

Kyanite is being mined by the Vitrefrax Corporation, three miles northeast of Ogilby, on the western slope of the Cargo Muchacho Range, Imperial County. The mineral also occurs in Tuolumne County.

Sillimanite is found in Inyo, Los Angeles, Mariposa, San Bernardino, San Diego, and Tuolumne counties but not in commercial quantities.

Dumortierite occurs in Imperial, Riverside and San Diego counties. The main commercial supply comes from Oreana, Pershing County, Nevada.

PREPARATION - The preparation of andalusite for refractories as carried out by the Detroit plant of the Champion Porcelain Co. is essentially as follows: The ore is crushed and ground until there are about equal proportions by weight of 8 to 14 mesh, 14 to 30 mesh, and less than 30 mesh. This material is then passed over a magnetic separator and screened ready for mixing with clay or other aluminous binder. This is followed by moulding into the desired shapes and firing at 1450°C or higher.

When andalusite is used in porcelain, it is ground until 60 per cent is 325 mesh and finer, the remainder having the maximum size of 30 mesh. This product is mixed with flux, clays and water in a pebble mill until it passes a 325 mesh lawn (a fine silken sieve). It is then passed over a magnetic separator and pressed in a filter-press until enough water is eliminated so that the material may be handled and stored in an aging cellar for use in ceramics.

Kyanite is apt to be friable when calcined and is difficult to bond. Calcination is necessary before it can be used due to the expansion which takes place when the material is heated to about 1350°C. At the same time the specific gravity (3.6) drops to that of a mixture of mullite and glass (3.1). (Riddle).

The Vitrefrax Corporation has developed a method for treating the kyanite ore mined at Ogilby, which takes advantage of the fact that small needle like grains of kyanite swell slightly and elongate considerably when converted to mullite. If incorporated in a ceramic object before elongation they elongate during firing and increase the mechanical strength of the body. This works best if the crystals are heated just below the conversion point, then incorporated. (Riddle).

Andalusite, kyanite, sillimanite, and dumortierite may be converted to mullite ($3Al_2O_3.2SiO_2$) when fused. This change (according to Petar I.C. 6255) does not take place at any definite temperature but progresses slowly over a considerable range.

Andalusite begins to change to a mixture of mullite and silica at about 1400°C, the conversion of kyanite begins at about 1200°C and that of sillimanite begins at around 1600°C.

Dumortierite is converted to mullite at approximately 1500°C.

USES - The most important use of andalusite is in the manufacture of porcelain for spark plugs. It is also used for laboratory ware which must be heat resistant.

Kyanite when converted to mullite, has been used experimentally for spark plug porcelain. Refractory brick, electrical porcelain, chinaware, glass and enamelware are made all or in part of kyanite.

Dumortierite burns to a nearly pure white product, increasing the toughness and electrical resistivity of porcelain. It allows a greater temperature range in burning than does andalusite according to Dr. J. A. Jeffery in I. C. 6255. He also states that "porcelain made from a mixture of dumortierite and andalusite has a very low coefficient of expansion."

Refractory bricks made of dumortierite alone gradually swell and those made of andalusite tend to sag so that a mixture of the two materials produces a very durable brick.

Mullite, made from andalusite, is used extensively in the glass blowing industry for tanks to hold molten glass. Other uses of mullite are for electric furnaces and muffles or any parts which must be rigid and non-shrinking at high temperatures.

Ramming mixes or plastic patches for metallurgical processes consist of ground andalusite, a binder, and a definite amount of water thoroughly mixed and shipped in sealed containers to preserve the original physical condition.

TESTS - Andalusite, kyanite, sillimanite, and dumortierite turn blue when a small fragment is intensely heated with cobalt nitrate on charcoal. This is the standard test for infusible aluminum minerals.

The best method for detecting the boron in dumortierite is to mix some of the powdered mineral with boron flux (one part powdered fluorite to two parts potassium bisulfate). Then slightly moisten the mixture and, using a platinum wire, pick up a little of the material and hold it in a blow-pipe flame. Just at the moment of fusion a green flame appears which disappears almost immediately. A colored screen which eliminates yellow light, such as the Merwin screen, aids in viewing the green color.

Andalusite may usually be distinguished by the nearly square prismatic crystals. Kyanite may be recognized by its bladed form, blue color, and varying hardness. (The hardness of a few other tough fibrous minerals varies with the direction so that this characteristic is not too reliable). Sillimanite is characterized by its fibrous or columnar form.

Dumortierite often resembles tourmaline and optical tests may be necessary to distinguish it. The fibrous habit is characteristic.

MARKETS:

Champion Sillimanite, Inc., mines all of the andalusite produced in California and the entire tonnage is consumed by the parent company, Champion Spark Plug Company.

The total tonnage of California kyanite is mined and consumed by the Vitrefrax Corporation.

Domestic kyanite sales as reported to the U. S. Bureau of Mines (Minerals Yearbook, Review of 1940) averaged $22.10 per short ton f.o.b. mines.

POSSIBLE BUYERS

The following list of possible buyers was furnished by Dr. J. A. Jeffery, Vice-President and General Manager, Ceramic Division of the Champion Spark Plug Company:

Vitrefrax Company, Los Angeles, California
Coors Porcelain Company, Golden, Colorado
Denver Fire Clay Company, Denver, Colorado
A. P. Green Fire Brick Company, Mexico, Missouri
Laclede-Christy Clay Products Company, St. Louis, Missouri
The Charles Taylor Sons Company, Cincinnati, Ohio
Mullite Refractories Company, Shelton, Connecticut
Electro Refractories & Alloy Corporation, Niagra Falls, New York.
Corhart Refractories Company, Louisville, Kentucky
Corning Glass Company, Corning, New York.
Hartford-Empire Company, Hartford, Connecticut.
General Refractories Company, Philadelphia, Pennsylvania
The Refractories Corporation, Los Angeles, California (Successor to Tillotson Clay Products Company)

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Petar, Alice V. Sillimanite, Kyanite, Andalusite, and Dumortierite. U. S. Bureau of Mines Information Circular 6255, March 1930.

Pabst, Adolf. Minerals of California, California State Division of Mines Bulletin 113, 1938.

Sampson, Reid J., and W. B. Tucker. Feldspar, Silica, Andalusite, and Cyanite Deposits of California. California State Mineralogist's Report 27, pp 407-458, 1931.

Schaller, W. T. Dumortierite. U. S. Geological Survey Bulletin No. 262, 1905.

Riddle, Frank Harwood. Mining and Treatment of the Sillimanite Group of Minerals and Their Use in Ceramic Products. Transactions of the A. I. M. E., Vol. 102, 1932.

Dietrich, Waldemar Fenn. The Clay Resources and Ceramic Industry of California. California State Division of Mines Bulletin 99, 1928

Peck, A. B. Changes in the Constitution and Microstructure of Andalusite, Cyanite, and Sillimanite at High Temperatures and Their Significance in Industrial Practice. Journal American Ceramic Society Vol. 8, pp 407, 1925.

NOTES:

Specimens of andalusite, kyanite, sillimanite, and dumortierite may be seen in the museum of the California State Division of Mines museum, Ferry Building, San Francisco.

State of California
Department of Natural Resources
DIVISION OF MINES

Walter W. Bradley
State Mineralogist

SEPTEMBER - 1942

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

ANTIMONY

By
George L. Gary, Mineral Technologist

PROPERTIES - Stibnite (Sb_2S_3), is the most common antimony mineral and the chief source of the metal. When pure it contains 71.7 percent antimony. It occurs in confused aggregates or radiating groups of acicular vertically striated crystals; massive, coarse or fine columnar, commonly bladed, less often granular to impalpable. The luster is metallic, highly splendent on cleavage or fresh crystalline surfaces. Color and streak lead-gray; cleavage perfect in one direction. The hardness is 2. and the specific gravity varies from 4.52 to 4.62.

OCCURRENCE - Stibnite is of primary origin and is found most commonly in veins with quartz. The contents of these veins were deposited from alkaline solutions at comparatively shallow depths. The veins frequently occur in granitic rocks. It is sometimes found as beds in schists, as a replacement in limestone, in hot spring deposits and in deep-seated veins lying in or near intrusive rocks. Besides quartz, the associated minerals include other antimony compounds, galena, sphalerite, silver ores, pyrite, barite, calcite, realgar, and cinnabar. It often alters to various antimony oxides. Good deposits of stibnite exist in California; recent shipments being made from properties in Inyo, Kern, and San Bernardino counties. Other counties where stibnite occurs in possible commercial quantities are Calaveras, Contra Costa, Lake, Los Angeles, Mariposa, Merced, Mono, Monterey, Napa, Nevada, Placer, Riverside, San Benito, San Diego, San Luis Obispo, Santa Clara, Sierra, Sonoma, Trinity and Tulare counties. There are notable deposits of the native metal in the Kernville and Havilah districts of Kern County, being among the few localities of the world where native antimony has been found. There are a number of other antimony minerals, but they are found in only small quantities, associated with stibnite, and are not of any particular commercial importance, as they are never found alone in paying quantities and, in association with stibnite, they do not materially affect the treatment processes.

PREPARATION - Antimony metal may be produced by the direct smelting of ore, of liquidated sulfide (crude), or of the oxides obtained from the roasting process. The Menardi Metals Co., have a smelter in Los Angeles where refined antimony is produced and there is a smelter in Laredo, Texas, producing antimony metal. The Bureau of Mines has developed an electrolytic method for improving the recovery of antimony from antimony-gold ores.

ANTIMONY (continued)

USES - METALLURGICAL: From 75 to 80 percent of the total antimony consumption is in the form of an alloy with lead which is applicable to a wide variety of uses, the most important of which are: Storage battery plates; sheet and pipe in chemical industries; and the sheathing of cables for telephone, telegraph and other uses. Its use in type metal is probably the most important service which antimony has rendered to mankind, although amounts used are far less than in some other applications. CHEMICAL: The most used compounds of antimony are the oxides and the sulfides which are used as paint pigments and as coloring agents in glass. A number of salts of antimony are used medicinally, the most important being tartrate of antimony and potassium, commonly known as tartar emetic. MILITARY: Shrapnel balls and bullet cores are hardened with varying percentages of antimony. The bursting charge of shrapnel shells contains antimony sulfide which produces a dense white smoke on explosion, thus enabling the location of the burst to be observed. Another important use of the sulfide is the priming mixture for the detonating caps of rifle and artillery cartridges.

TESTS: Antimonial minerals roasted on charcoal give dense white odorless fumes; metallic antimony and its sulfur compounds give in the open tube a white sublimate of oxide of antimony. Antimony sulfide (stibnite),also many sulphantimonites, give in a strong heat in the closed tube a sublimate of antimony oxysulphide, black when hot, brown-red when cold. Gives iodide test on plaster, orange to red. Sublimate disappears when subjected to ammonia fumes. In nitric acid, compounds containing antimony deposit white insoluble metaantimonic acid.

MARKETS - Antimony Ore - Per unit of antimony contained, 50 to 55 percent, $2.15 @ $2.20; 58 to 60 percent, $2.20 @ $2.30; 60 to 65 percent, $2.30 @ $2.40.

POSSIBLE BUYERS

American Smelting & Refining Co., 120 Broadway, New York, N. Y.
Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, N.
F. H. Dakin, 2811 Hillside Drive, Burlingame, California.
E. I. du Pont de Nemours & Co. (The R. & H. Chemicals Department), Wilmington, Del.
Stanley Fullwood, 10 East 40th St., New York, N. Y.
Charles Gitlan & Co., Inc., 25 Beaver St., New York, N. Y.
Charles Hardy, Inc., 415 Lexington Ave., New York, N. Y.
The Harshaw Chemical Co., Cleveland, Ohio.
The O. Hommel Co., Inc., 209 Fourth Ave., Pittsburgh, Pa.
Industrial Sales Corp., 60 East 42nd St., New York, N. Y.
International Selling Corp., 26 Beaver St., New York, N. Y.
Morris Kirk & Sons, 2717 So. Indiana St., Los Angeles, California
The McGean Chemical Co., 1106 Republic Bldg., Cleveland, Ohio.
Menardi Metals Co., 2310 E. 52nd St., Los Angeles, California.

ANTIMONY (continued)

Mercantile Import & Export Corp., 21 East 40th St., New York, N. Y.
Metal & Thermit Corp., 120 Broadway, New York, N. Y.
National Lead Co., 111 Broadway, New York, N. Y.
Rare Metal Products Co., Belleville, N. J.
C. Solomon, Jr., 314 Battery St., San Francisco, Calif.
C. Tennant Sons & Co., of New York, 9 Rockerfeller Plaza, New York, N.Y.
Texas Mining & Smelting Co., P.O. Box 559, Laredo, Texas.
The Vitro Manufacturing Co., Corliss Station, Pittsburgh, Pa.
Wah Chang Trading Corp., 233 Broadway, New York, N. Y.
Whittaker, Clark & Daniels, Inc., 260 West Broadway, New York, N. Y.
Wishnick-Tumpeer, Inc., 295 Madison Ave., New York, N. Y.
Paul W. Wood Company, 447 Hampshire St., San Francisco, Calif.

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Donald E. White. Antimony Deposits of the Wild Rose Canyon Area. Inyo County, California. U. S. Geological Survey Bulletin 922-K. (1940).

NOTE

Specimans of antimony ores may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | MARCH - 1942 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

ARSENIC

By
George L. Gary, Mineral Technologist

PROPERTIES - Arsenopyrite, a sulfarsenide of iron, FeAsS, (arsenic 46.0 per cent, sulfur 19.7 per cent, iron 34.3 per cent) is found in well-formed crystals, disseminated grains, columnar forms, and compact masses. Luster, metallic. Color tin white to light steel-gray. Hardness 5½ to 6. Specific gravity 5.9 to 6.2.

Realgar, arsenic sulfide, AsS, contains 70.1 per cent arsenic, 29.9 per cent sulfur. The crystals are short prismatic and striated vertically. It is also found granular massive and as incrustations. Sectile. Resinous luster. Color, bright red to orange yellow. Streak orange yellow. Hardness 1½ to 2. Specific gravity 3.56.

Orpiment, arsenic trisulfide, As_2S_3 contains 61.0 per cent arsenic, 39.0 per cent sulfur. It occurs usually in foliated masses and as powdery incrustations. Cleavage is perfect in one direction. Sectile. Pearly luster. Color, lemon yellow. Streak pale yellow. Hardness 1½ to 2. Specific gravity 3.4 to 3.5.

Scorodite, a hydrous ferric arsenate, $FeAsO_4.2H_2O$, usually occurs in drusy crystalline aggregates or in fine granular to compact masses. It may be earthy. Color, green, grey-green, greenish brown to brown. The luster is vitreous. Hardness 3½. Specific gravity 3.1 to 3.4.

OCCURRENCE - Arsenopyrite is a common vein mineral and is found in the concentrates from most of the mining regions of the State. In some districts it is the chief gold-bearing mineral.

Realgar occurs as a vein mineral and is often associated with orpiment to which it readily alters. It has not been found in any quantity in the State.

Scorodite usually occurs in the oxidized zone of ore bodies as an alteration product of arsenopyrite. It is not common in California, having been found only in three counties.

PREPARATION - Metallic arsenic is produced by the sublimation of arsenopyrite in the absence of air, and by the reduction of arsenic trioxide with charcoal in cast iron or steel retorts. The temperature and pressure in the retort must be carefully controlled in order to yield crystalline arsenic.

Geology of California
Department of Mineral Resources

Division of Mines

Olaf P. Jenkins	Edwin H. Lee	Percy Perkins
State Mineralogist		Ben Pratchler

CHARACTER SYSTEMS OF MALACOLOGY
(Chapter 1970)

by

George W. Grey, Harvard University

[illegible]

ARSENIC (continued)

When arsenic bearing minerals are roasted, the arsenic is volatilized and passes off with the gases. Arsenic trioxide or white arsenic then condenses in the cooler part of the flue system (about 218°C). This process takes place in copper or lead smelter flue systems which furnish the major portion of the world's arsenic supply.

Lead arsenate may be prepared in a number of ways, one of which is to precipitate it by adding a soluble lead salt to a sodium arsenate solution.

Arsenic trioxide may be converted to sodium arsenate from a solution of which calcium arsenate may be precipitated by calcium oxide.

USES - Most of the world's production of arsenic is used as lead arsenate or calcium arsenate in insecticides, weed killers, and wood preservatives. Calcium arsenate has been very effective in combating the boll weevil which is so destructive to cotton plants.

A small amount of white arsenic is used in the manufacture of glass. Realgar, both natural and artificial, is used as a pigment in paints.

TESTS - When arsenic occurs in a mineral as an arsenate, such as in scorodite, it may be detected by the garlic odor which is given off when a mixture of the powdered mineral with charcoal dust and sodium carbonate is heated in the reducing flame on charcoal. The same mixture heated in a closed tube will yield a sublimate of metallic arsenic.

Other arsenic minerals give off fumes and the characteristic garlic odor when roasted alone on charcoal. In the open tube they give a white, volatile, crystalline sublimate of arsenic trioxide. In the closed tube arsenic sulfide gives a sublimate which is dark brown-red when hot and red or reddish yellow when cold.

MARKETS - White arsenic (arsenious oxide) delivered in carload lots is 4¢ per lb; Calcium arsenate, in bags, carload lots, per lb. 7 - 8¢; less than carload lots per lb. 7½ - 8½¢. Lead arsenate, barrels, carload lots, per lb. 11 - 12¢; less than carload lots, in bags, per lb. 11½ - 12½¢. (Quotations, February 1942).

POSSIBLE BUYERS:

American Smelting & Refining Company, 120 Broadway, New York, N.Y.
Bartlett Chemicals, Inc., 923 Tchoupitoulas St., New Orleans, La.
Bauer Co. Inc., Philipp, 18 East 41st St., New York, N. Y.
Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, N. Y.
Buck Inc., Leonard J. 1 Newark Avenue, Jersey City, N. J.
Drakenfeld & Co. Inc., B.F. 45 Park Place, New York, N. Y.
Hardy Charles, Inc., 420 Lexington Avenue, New York, N. Y.
Industrial Sales Corporation, 295 Madison Avenue, New York, N. Y.
McKesson & Robbins Inc., Heavy Chemicals Division, 155 East 4th St. New York, N. Y.
Ore & Chemicals Corp. The.- 80 Broad Street, New York, N. Y.

(Continued)

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POSSIBLE BUYERS (cont'd.)

Pfaltz & Bauer, Inc., Empire State Building, New York, N. Y.
Philipp Brothers Inc., 70 Pine Street, New York, N. Y.
Republic Chemicals Corporation, 94 Beekman St., New York, N. Y.
Wood J. Early, 50 Pine Street, New York, N. Y.

REFERENCES:

Lidell, Donald M. Handbook of Nonferrous Metallurgy. Vol. II. Chapter on Arsenic by Walter C. Smith. McGraw-Hill Book Company, New York, N. Y., 1926.

Pabst, Adolf. Minerals of California. California State Division of Mines Bulletin 113, 1938.

Tyler, Paul M., and Petar, Alice V. Arsenic. U. S. Bureau of Mines Economic Paper No.17, 1934.

NOTES:

1. Specimens of the arsenic minerals may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Some arsenic minerals of little importance in California are arsenolite (As_2O_3), claudetite (As_2O_3).

3. A few of the other arsenic bearing minerals in which the arsenic occurs as a non-metal are niccolite (NiAs), cobaltite (CoAsS), proustite (Ag_3AsS), enargite (Cu_3AsS_4) and mimetite ($Pb_5Cl(AsO_4)_3$).

Reference Number (continued)

Holley & Dewey, Engrs., Empire Fire Building, New York, N. Y.
Printing Industry Ind., 70 Fifth Avenue, New York, N. Y.
Reynolds Chemicals Corporation, 700 Madison Ave., New York, N. Y.
Mary J. Kelly, 30 Rine Street, New York, N. Y.

BIBLIOGRAPHY:

Blaisdell, Donald M. Handbook of Engineering Mathematics, Vol. II.
Chapter on Arrays, by Wayne D. Smith. Blaisdell Book
Company, New York, N. Y. 1963.

Byrne, Albert. Manual of Chemistry. Philadelphia Book Division
of Blaine Publishing Co., 1959.

Taylor, Prof M., and Wright, Alice V. Geometry. N. Y. Bureau of
Higher Education Press, Inc., N.Y. 1964.

NOTES:

1. Proof sets of the regular currency may be ordered by the
Bureau of the Chairman Alvin Brinkman of Plano, Printing Division,
Room Publishing, Dallas.

2. Some Security engraving is still done by the
Treasury (Bureau), Washington (Ave Old).

3. A few of the other currency Security elements is widely
[illegible] printed on a non-paper rag element [illegible], consisting
[illegible] material (Cotton), printed (Linen) and chemical
[illegible].

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | JULY - 1941 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

ASBESTOS

By
George L. Gary, Mineral Technologist

PROPERTIES - The term asbestos (from the Greek for incombustible) is given to several fibrous varieties of amphibole and to the fibrous serpentine, chrysotile, Tremolite, a calcium-magnesium amphibole, $Ca_2Mg_5Si_8O_{22}(OH)_2$ and actinolite, a calcium-magnesium-iron amphibole, $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)$ have a hardness of 5-6 and a gravity of 2.9-3.2. The luster is vitreous; color varying from white in tremolite to light green in actinolite; the color deepens with increase in the amount of iron present. In the asbestos of fibrous varieties of these minerals the fibers are sometimes very long, fine, flexible, and easily separable by the fingers, and look like flax. The name amianthus is applied usually to the finer and more silky kinds. Byssolite is a stiff fibrous variety. Much that is popularly called asbestos is chrysotile, a fibrous serpentine, $Mg_3Si_2O_5(OH)_4$. The hardness is 2.5-4; the gravity 2.22. The luster is silky or silky metallic; color greenish white, green, olive-green, yellowish and brownish. It is delicately fibrous, the fibers usually flexible and easily separating.

OCCURRENCE - Asbestos is commonly found in three forms, according to the mode of occurrence. Cross-fiber, when the fibers are arranged normal to the vein walls; the fiber length is thereby limited to the vein width and is often less, due to a break, or parting in the vein. Slip-fiber, when the fibers lie in the same plane as the vein or slippage plane, upon which it is formed; mass-fiber, when formed as an aggregate of interlaced unoriented fibers, or as stellate groups of radiating needles. Tremolite is always a product of metamorphism and is especially common in limestones, particularly the magnesian or dolomitic varieties. It also occurs as an alteration product of pyroxene or olivine in serpentines, etc. Actinolite is common in schists, in steatitic rocks, and with serpentine; it also is found as secondary mineral in certain igneous rocks, produced by the alteration of pyroxene, etc. Chrysotile occurs as narrow veins in serpentine which is an alteration product of basic igneous rocks rich in magnesian silicates.

ASBESTOS (Continued)

PREPARATION - When the ore is broken in mining some pieces of vein material are picked up by hand; lumps retaining portions of the wall rock are freed by the blow of a hammer. Further recovery is effected on picking belts or tables before or after the primary crusher. In the milling of asbestos after cobbing, the rock is dried, crushed and screened leaving the asbestos in a fluffed condition which is removed by a current of air. Further screening and grading is necessary before the asbestos is bagged.

USES - Amphibole asbestos possesses high refractory properties, but lacks strength of fiber; its use is restricted to heat insulation, chemical filters, and as a filler, while serpentine asbestos fibers are often of silky finess, and have greater strength and elasticity and may be spun into threads or woven into cloth. About 95 percent of the asbestos produced is serpentine asbestos (chrysotile). The asbestos of long enough fiber to permit spinning is made into heat-resisting fabrics for various purposes, the most important of which is brake lining for automobiles. The lower-grade, shorter-fiber asbestos is used for insulating purposes, asbestos shingles, wick, rope packing, etc. The many uses for which asbestos is so peculiarly adapted make it invaluable to industry; it withstands fire and insulates against heat and sound; it is light in weight, and can be made into pliable fabrics; it resists soil corrosion and the attack of vermin.

TESTS - The amphibole asbestos is fusible at 3-4. After decomposition with sodium carbonate will give tests for calcium and magnesium (tremolite) and iron, calcium and magnesium (actinolite). Both yield water in the closed tube. The serpentine asbestos is infusible. Decomposed by hydrochloric acid with the separation of silica but without the formation of a jelly. Filtered solution, after having any iron precipitated by ammonium hydroxide, gives a precipitate of ammonium-magnesium phosphate with sodium phosphate. Water in a closed tube.

MARKET - To bring the highest market price, asbestos must possess the following properties: toughness or tensile strength, infusibility, flexibility, length of fiber and fineness of fiber. Asbestos - Per ton, f.o.b. Quebec mines, tax and bags included: Crude No. 1, $700 @ $750; Crude No. 2 and sundry crudes, $150 @ $350; spinning fibers, $110 @ $200; magnesia and compressed sheet fibers, $110 @ $200; various grades shingle stock, $57 @ $85; various grades paper stock, $40 @ $49; cement stock, $22 @ $30; floats, $19 @ $21; shorts, $13 @ $17.50. Quotations in U. S. funds. Per ton, f.o.b. mines. Vermont: shingle stock, $57 @ $60; paper stock, $40 @ $48; cement stock, $25; shorts and floats, $13 @ $18. (Quotations June 1941)

ASBESTOS (Continued)

POSSIBLE BUYERS

The Burnet Company, 100 Gold St., New York, N. Y.
Foote Mineral Co., Inc., 1607 Summer St., Philadelphia, Pa.
International Pulp Co., 41 Park Row, New York, N. Y.
Johns-Manville Corp., 22 East 40th St., New York, N. Y.
Jones Bros. Asbestos Company, 333 - 7th Street, San Francisco, Calif.
D. H. Litter Co., 500 Fifth Ave., New York, N. Y.
The Philip Carey Co., Lockland, Cincinnati, Ohio.
Plant Rubber & Asbestos Works, 537 Bryant St., San Francisco, Calif.
Western Asbestos Company, 675 Townsend St., San Francisco, Calif.
Whittaker, Clark & Daniels, Inc., 260 West Broadway, New York, N. Y.
Wishnick-Tumpeer, Inc., 295 Madison Ave., New York, N. Y.

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Oliver Bowles and K. G. Warner. Asbestos. Minerals Yearbook 1940, pp. 1363-1372.
Adolf Pabst. Minerals of California. Calif. State Division of Mines, Bulletin No. 113 (1938).
J. G. Ross. Chrysotile Asbestos in Canada. Mines Branch, Dept. of Mines, Canada, Mem. 707 (1931), 146 pp.
J. G. Ross and George F. Jenkins. Asbestos. Industrial Minerals and Rocks. The American Institute of Mining and Metallurgical Engineers, New York. (1937) pp. 75-96.

NOTES

1. Specimens of asbestos may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Anthophyllite, $(Mg,Fe)SiO_3$, crocidolite, $NaFe(SiO_3)_2.FeSiO_3$ and amosite, an iron-rich amphibole, without the sodium molecule of crocidolite and, except for its higher iron content, similar in composition to anthophyllite, occur in sufficiently fibrous form to be generally recognized as asbestos.

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BIBLIOGRAPHY (Continued)

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley State Mineralogist	SEPTEMBER - 1941	Ferry Building San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

BARIUM

By
George L. Gary, Mineral Technologist

PROPERTIES - Only two minerals of barium are produced commercially - barite, a barium sulfate, $BaSO_4$; and witherite, a barium carbonate, $BaCO_3$. Barite when pure contains 65.7 percent BaO and 34.3 percent SO_3. Strontium and calcium sulfates are present in some specimens. It occurs frequently in divergent groups of tabular crystals; also coarsely laminated, granular and earthy. Streak and color white, sometimes yellowish or grayish. The fracture is uneven and the mineral is brittle. The hardness is 2.5 - 3.5 and the specific gravity is 4.3 - 4.6. Witherite when pure contains 77.7 percent BaO and 22.3 percent CO_2. It occurs in twinned crystals. Also massive, columnar and granular. Streak and color white; sometimes yellowish or grayish. The fracture is uneven and the mineral is brittle. The hardness is 3.5 and the specific gravity is 4.3.

OCCURRENCE - Barite is a common mineral of wide distribution. It occurs usually as a gangue mineral in metallic veins, associated especially with ores of silver, lead, copper, cobalt, manganese and antimony. It is found in veins in limestone with calcite, or as residual masses in clay overlying limestone. Also in sandstone with copper ores. In places acts as a cement in sandstone. Deposited occasionally as a sinter by waters from hot springs. Barite is widely distributed in California, being noted in 29 of the 58 counties in the state. A large deposit of barite with witherite about 2 miles west of El Portal, Mariposa County, has yielded much of the barite mined in California. Witherite has also been found on Beegum Creek, near Platina, Shasta County.

PREPARATION - Barite is sold or marketed in the form of crude lumps, jigged concentrates or table concentrates. Lump ore may be prepared from residual deposits or from vein deposits. It is essentially a product of hand sorting. With ore from veins the waste rock or gangue is sorted out with possibly some hand cobbing, either on platforms or picking belts. In one California mine where witherite occurs with the barite, the two minerals are sorted or separated by hand. In the preparation of ground barite, the crude

BARIUM (continued)

material is first crushed to about one inch size, and then washed in jigs or similar machines to remove the clay, calcite, silica, iron oxide, etc. It is then ground fine and bleached by treating with sulfuric acid for 8 to 12 hours in lead-lined tanks. The bleaching process is a very important one as the product must have a perfectly uniform color. After bleaching it is washed several times and then pulverized to pass a 200 or 300 mesh screen, and in some cases is water floated to insure a uniformly fine product. It is then dried and packed. Lithopone is an intimate mixture of about 70 percent barium sulfate, 25 to 29 percent zinc sulfide and 1 to 5 percent zinc oxide, made by the coprecipitation of solutions of barium sulfide and zinc sulfate. The precipitate is filtered, dried with great heat, then placed in water and ground to a pulp, after which it is filtered, dried and packed.

USES - The largest use of barium is in the chemical lithopone, which is used in the paint industry and to a lesser extent in floor coverings and textiles. Precipitated barium sulfate, "blanc fixe," is used as a filler in paper and cloth, in cosmetics and as a paint pigment. Crushed barite is used extensively in making a sludge of high specific gravity to support tools during drilling operations of deep oil wells. Barite is the raw material for the manufacture of most barium chemicals, although witherite is used when available. Precipitated barium carbonate is used in the ceramic industry and for making barium peroxide. Other important barium chemicals are the nitrate, chloride, hydrate, dioxide, peroxide, chromate and chlorate. Small amounts of metallic barium are used in some special alloys.

TESTS - A yellowish green coloration of the flame is given by all barium salts, except the silicates; an alkaline reaction is usually obtained after igneous ignition. In solution the presence of barium is proved by the heavy white precipitate ($BaSO_4$) formed upon the addition of dilute sulfuric acid.

MARKETS

Barium Carbonate (Witherite) - Per ton, 90 percent 300 mesh, $43.

Barite - F.o.b. mines: Georgia: Barite ore, crude, $8 per long ton. Missouri: Per ton, water ground and floated, bleached, $22.85, carlots, f.o.b. works. Crude ore, minimum 95 percent $BaSO_4$, less than 1 percent iron, $6.25 @ $7.00; 93 percent $BaSO_4$, $6 @ $6.35, f.o.b. mines. (Quotations, September, 1941).

(continued)

POSSIBLE BUYERS

American Cyanamid & Chemical Corp., 30 Rockefeller Plaza, New York, N. Y.
Barium Products, Ltd., Modesto, Calif.
Baroid Sales Division—National Lead Co., 830 Ducommun St., Los Angeles, Calif.
Chemical & Pigments Co., 776 - 50th Ave., Oakland, Calif.
Consolidated Minerals Co., P. O. Box 92, Long Island City, N. Y.
De Lore Division, National Lead Co., Mississippi River & River Des Peres, St. Louis, Mo.
W. P. Fuller & Co., 301 Mission St., San Francisco, Calif.
Industrial Minerals & Chemical Co., Sixth and Gilman St., Berkeley, Calif.
Joseph A. McNulty, 114 Liberty St., New York, N. Y.
Mercantile Import & Export Corp., 21 East 40th St., New York, N. Y.
National Lead Company, 111 Broadway, New York, N. Y.
National Pigments & Chemical Div. (National Lead Co.), 830 Ducommun St., Los Angeles, Calif.
National Pigments Co., Russ Bldg., San Francisco, Calif.
C. J. Osborn Co., 132 Nassau St., New York, N. Y.
L. A. Salomon & Bro., 216 Pearl St., New York, N. Y.
F. E. Schundler & Co., Inc., 620 Railroad St., Joliet, Ill.
Smith Chemical & Color Co., 55 John St., Brooklyn, N. Y.
Synthetic Iron Color Co., Richmond, Calif.
Thompson, Weinman & Company, Inc., 52 Vanderbilt Ave., New York, N.Y.
Western Talc Co., 1901 E. Slauson Ave., Los Angeles, Calif.
Whittaker, Clark & Daniels, Inc., 260 West Broadway, New York, N. Y.
C. K. Williams & Co., 640 North 13th St., Easton, Pa.
Wishnick-Tumpeer, Inc., 295 Madison Ave., New York, N. Y.

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Adolf Pabst. Minerals of California. Calif. State Div. of Mines, Bulletin No. 113 (1938).
W. M. Weigel. Barium Minerals. Industrial Minerals and Rocks. The American Institute of Mining and Metallurgical Engineers. New York. 1937, pp. 97-110.

NOTE

Specimens of barium ores may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | OCTOBER - 1942 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

BENTONITE

By
George L. Gary, Mineral Technologist

PROPERTIES - Bentonite is composed principally of montmorillonite $(Mg,Ca)O.Al_2O_3.5SiO_2.nH_2O$, which is a massive clay-like, microcrystalline mineral of white, gray, greenish, or reddish color. It is exceedingly fine grained, very plastic, and highly absorbent. When moistened, it absorbs about three times its weight of water and expands ten or more times its original volume. Exposed surfaces are dull and powdery but a freshly cut surface usually has a waxy luster. It is easily fusible and is very soft. Specific gravity 2.5.

OCCURRENCE - Most bentonite is formed by the alteration of volcanic ash, but some deposits are due to the devitrification of lavas and related rocks.

Bentonite outcrops are usually barren of vegetation and often present a crinkled coral-like appearance due to expansion after becoming wet. Immediately after a rain bentonite outcrops are frequently covered with a thick mass of slippery jelly, but in dry weather the surface may be dry and fluffy or may have a granular appearance.

In California, bentonite is found in Inyo, Kern, Los Angeles, San Luis Obispo, San Benito, San Bernardino, San Diego, and Ventura counties, and has been produced from all except Los Angeles County.

The deposits of montmorillonite on the mesas of both sides of the Otay River Valley, San Diego County, form a layer from two to six feet thick a few feet below the surface of the mesa, and underlie several hundred acres.

The extensive beds of bentonite along the Amargosa River in the vicinity of Tecopa, Shoshone, and Ash Meadows in Inyo County, are from one to ten feet thick.

Bentonite in San Bernardino County occurs between Barstow and Daggett in masses of from ten to two hundred tons each.

PREPARATION - With the exception of the activable bentonites, the only treatment necessary is washing to remove impurities such as sand, gypsum, carbonaceous matter, etc. Much of the wash water is absorbed by the bentonite which necessitates a long and expensive drying period.

Activated bentonite (a substitute for fullers earth and other bleaching clays) is prepared by treating the clay with hydrochloric or sulfuric acid (usually sulfuric acid as it is cheaper). When the material loses its bleaching power it may be reactivated and used again.

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

Ferry Building
San Francisco

COMMERCIAL PUMICE OF CALIFORNIA
(Circular 1961)

By
George L. Burr, Mineral Technologist

ABSTRACT - Pumice is composed principally of microcrystalline glass, which, when in a massive form, is commonly white, occasionally buff or gray, and rarely pink. It is extremely light, very porous, and highly absorbent. When ground, it weighs about three times as much as the same volume of water and expands to four or more times its original volume. Pumice deposits are widely distributed and in very much demand. Pumice sand is very lucrative. It is easily handled and in very much demand.

CONTENTS - Text begins on page 3.

Introduction
Uses of pumice
Occurrence
Production
Prices
Bibliography

INTRODUCTION

Pumice is a volcanic glass, usually light gray or white, but sometimes buff, pink, or black. It is extremely light, very porous, and highly absorbent. When ground, it weighs about three times as much as the same volume of water and expands to four or more times its original volume. Pumice deposits are widely distributed and in very much demand. Pumice sand is very lucrative. It is easily handled and in very much demand.

USES - The oil refining industry consumes the greater tonnage of bentonite which after activation is used as a bleaching agent. The raw or untreated material is used for filtering in oil refineries. It is also in demand for use in rotary well-drilling mud.

Bentonite is important during the present national emergency because of its use in foundry molding sands. It has bonding properties far greater than other clays, so that less clay is required in the sand, thus allowing more free space between the grains for the rapid escape of steam and gases created during pouring of the metal.

Other less important uses are in cement, for sealing earth dams, for filtering water, for cosmetics, and in horticultural sprays.

Experiments conducted in 1938 (See Minerals Yearbook 1939. Review of 1938, pp 1213) showed that bentonite may be used as a substitute for mica in a number of cases. The material is known as "alsifilm".

There are many other minor uses for bentonite and new ones are being discovered continually.

TESTS - Bentonite may be recognized by its swelling action in water. It gives standard tests for aluminum, magnesium, and silica.

MARKETS - Bentonite - per ton, carload lots, f.o.b. Wyoming mines, dried and crushed, in bulk, $7.50. Pulverized, 200 mesh, $9.50, in 100-lb. paper bags. (Quotations as of September 3, 1942).

POSSIBLE BUYERS

Jerome Alexander, 50 East 41st St., New York, N. Y.
American Colloid Co., 365 West Superior St., Chicago, Ill.
American Cyanamid & Chemical Corp., 30 Rockerfeller Plaza, New York, NY.
Baroid Sales Division - National Lead Co., 830 Ducommun St., Los Angeles, California
Bartlett Chemicals, Inc., 923 Tchoupitoulas St., New Orleans, La.
Charles B. Chrystal Co., Inc., 18 Hudson St., New York, N. Y.
Coon Companies, Inc., 711 Gibbons St., Los Angeles, Calif.
Consolidated Minerals Co., P.O. Box 92, Long Island City, N. Y.
A. Daigger & Co., 159 West Kinzie St., Chicago, Ill.
Filtrol Corporation, 315 West Fifth St., Los Angeles, California.
Charles W. Garland Co., 412 West Sixth St., Los Angeles, California.
Hammill & Gillespie, Inc., 225 Broadway, New York, N. Y.
Innis, Speiden & Co., 117 Liberty St., New York, N. Y.
Kennedy Minerals Co., Inc., 2550 East Olympic Blvd., Los Angeles, Calif
Los Angeles Chemical Co., 1960 Santa Fe Ave., Los Angeles, California.
Milwhite Company, Inc., P. O. Box 1283, Houston, Texas.
Owyhee Chemical Products Co., 435 North Michigan Ave., Chicago, Ill.
Pacific Coast Talc Co., 2149 Bay St., Los Angeles, California.
The Pontian Bentonite Co., Inc., 27 Pearl St., New York, N. Y.
Prior Chemical Corporation, 420 Lexington Ave., New York, N. Y.
L. A. Salomon & Bro., 216 Pearl St., New York, N. Y.
F. E. Schundler & Co., Inc., 620 Railroad St., Joliet, Ill.
Southern California Minerals Co., 320 South Mission Road, Los Angeles, California.
Albert E. Starkie, 528 No. Cuyler Ave., Oak Park, Ill.
Tamms Silica Co., 228 No. La Salle St., Chicago, Ill.
United Clay Mines Corp., Prospect and Oakland Sts., Trenton, N. J.
Charles A. Wagner Co., Inc., 815 Callowhill St., Philadelphia, Pa.
Western Talc Co., 1901 East Slauson Ave., Los Angeles, California

MIMEOGRAPH (continued)

Whittaker, Clark & Daniels, Inc., 260 West Broadway, New York, N. Y.
Wishnick-Tumpeer, Inc., 295 Madison Ave., New York, N. Y.
The Wyodak Chemical Co., 4600 East 71st St. (Sta. D), Cleveland, Ohio.

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NOTE: Specimens of bentonite may be seen in the museum of the California State Division of Mines. Ferry Building, San Francisco, California.

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | AUGUST - 1942 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

BERYL

By
George L. Gary, Mineral Technologist

PROPERTIES - Beryl, $3BeO.Al_2O_3.6SiO_2$ occurs in hexagonal crystals usually long prismatic, often striated vertically, rarely transversely; distinct terminations exceptional. Occasionally in large masses, coarse granular or granular to compact. Cleavage: imperfect and indistinct. Fracture conchoidal to uneven. Brittle. Hardness 7.5 - 8.0. Specific gravity 2.63 - 2.80; usually 2.69 - 2.70. Luster vitreous, sometimes resinous. Colors emerald-green, pale green, passing to light blue, yellow and white; also pale rose-red. Streak white. Transparent to subtranslucent. Variety, 1. Emerald. Color bright emerald-green, due to the presence of a little chromium. 2. Ordinary; Beryl. Generally in hexagonal prisms, often coarse and large; green the common color. The principal kinds are: (a) colorless; (b) bluish-green, called aquamarine; (c) apple-green; (d) greenish-yellow to iron-yellow and honey-yellow; sometimes a clear bright yellow as in the golden beryl (a yellow gem variety from South West Africa has been called heliodor, containing a small amount of ferric oxide); (e) pale yellowish-green; (f) clear sapphire blue; (g) pale sky-blue; (h) pale violet or reddish; (i) rose colored called morganite or vorobyevite; (j) opaque brownish-yellow, of waxy or greasy luster. The oriental emerald of jewelry is emerald-colored sapphire.

OCCURRENCE - Beryl is obtained from pegmatite veins in granitic rocks from various parts of the world and is usually recovered as a by-product of such minerals as feldspar and mica. When pegmatites weather, many of their constituent minerals remain unattacked, and the heavier -- like monazite and tin and tungsten minerals -- may be concentrated in the residual mantle or transported to form placer deposits. Beryl, however, is as alterable as the feldspars. Although the beryllium content may reappear as a constituent of other secondary minerals, such as bertrandite, herderite, or beryllonite, none of these minerals is heavy enough to be separated by the sorting action of streams or other natural concentrating agencies, and consequently the beryllium is too diluted to be recovered on a commercial basis.

California Localities.

Fresno County: Beryl was reported to be associated with feldspar, 5 miles northeast of Trimmer. Inyo County : Blue crystals of beryl are reported to occur in quartz, in narrow pegmatite veins cutting granite, 6 miles south-southeast of Lone Pine. Riverside County: Fine yellow and green beryl was found at Coahuila and rose

beryl occurred near Hemet. Green and blue beryl crystals about half an inch long have been found in a pegmatite dike about 200 yards west of the Jensen limestone quarry, near Crestmore. San Diego County: Yellow, green, and blue crystals of beryl occur in the Palomar Mountains, 9 miles southeast of Pala. Rose, yellow, and green beryl crystals occur at Pala, Rincon and Mesa Grande. Pink beryl occurs at the Katrina mine, Pala and at Oak Grove. Fine large crystals of beryl have come from Aguanga Mountain. Golden and aquamarine beryl occurred at the Esmeralda mine. Fine crystals of beryl were found at the Surprise, A B C, Hercules, and Lookout mines, Ramona. Tuolumne County: Beryl has been reported from near Jamestown.

PREPARATION - The pure metal is prepared from beryllium oxide by an electrolytic process described in the circular on Beryllium and Beryl by Alice V. Petar which is listed in the bibliography.

USES - The principal use of beryllium is in the master alloy beryllium copper. The main advantages are the combination of extraordinary high-fatigue properties with good electrical conductivity. In contrast with certain competitive materials, it has the further advantage that it can be worked soft and hardened later instead of its hardness being rolled into it at the mill. Castings, low-spark tools and fabricated products also are produced. In addition to alloys the pure metal, and various beryllium compounds, such as the oxide, sulfate, nitrate and fluoride are produced. Notable commercial progress has been made with its high-fired flux-free oxide for use in ceramic materials, where good electrical resistance and thermal conductivity may be required.

TESTS - There are no satisfactory blowpipe reactions for beryllium, and tests must be made, therefore in the wet way, which requires some skill in manipulation.

a. If the mineral is a silicate, it may be decomposed readily by fusion with sodium carbonate and then dissolved. For a test, mix a scant ivory spoonful of the finely powdered silicate with 3 parts of sodium carbonate, make into a paste with a drop of water and then take up a portion of the material on a loop on platinum wire and fuse before the blowpipe. Make two or three beads, if necessary, rather than attempt to fuse all of the material at once. In almost all cases there results after fusion an opaque mass, the presence of various oxides contained in the mineral, mixed with the sodium silicate and excess of sodium carbonate, preventing the formation of a clear glass. The several beads, after removal from the platinum wire, are pulverized in a mortar, transferred to a test-tube, treated with about 1 cc. of water and an equal volume of nitric acid, and evaporated to dryness, being careful toward the end of the operation not to allow the tube to become very hot. After cooling, moisten the contents of the tube with about 3 cc. of hydrochloric acid, boil for a few seconds, so as to decompose any basic salts formed during the evaporation, then add 5 cc. of water, heat to boiling, and remove the insoluble silica by filtering. Then heat the filtrate from the silica to boiling, and precipitate the beryllium with ammonia, which will also cause precipitation of iron, aluminum, and possibly other

elements, if present. Ammonia precipitates beryllium hydroxide, which resembles aluminum hydroxide in appearance. This is filtered and washed well with water, transferred together with the paper to some vessel, and warmed with dilute hydrochloric acid in order to dissolve it. The paper is filtered off, and the filtrate evaporated carefully (best in a casserole) until only a drop or two of the acid is left. After cooling, a few drops of water are added to obtain everything in solution, and than a little potassium hydroxide solution, a drop at a time, and just sufficient to dissolve the precipitate of beryllium hydroxide which forms at first. The solution is then diluted with cold water to a volume of at least 50 cc. any precipitate of ferric hydroxide or other material filtered off, and the filtrate boiled for a short time, when, if beryllium is present, a precipitate of beryllium hydroxide will appear.

(b) If the mineral is a phosphate, special treatment is needed. The powdered mineral is dissolved in hydrochloric acid (after fusion with sodium carbonate, if necessary); when cold, ammonia is added until a permanent precipitate forms, and then hydrochloric acid, a drop at a time, until the solution becomes clear. To the now nearly neutral, cold, and not too concentrated solution, sodium acetate is added, and the precipitated beryllium phosphate, which may also contain ferric and aluminum phosphates, is filtered and washed. The precipitate is next ignited in a crucible until the carbon of the paper is destroyed, and is then fused in platinum with sodium carbonate, by which treatment sodium phosphate and beryllium oxide are formed. The fusion is then treated with hot water to dissolve the sodium phosphate, the beryllium oxide is collected on a filter-paper and washed, and it is afterwards dissolved in hydrochloric acid and tested with potassium hydroxide, as described under a. If it is known that the alkali-earth metals are absent, the mineral may be fused directly with sodium carbonate, and treated like the above sodium carbonate fusion.

(c) By quinalizarin. Fuse a minute amount of the material in a loop with a pellet of sodium hydroxide. When cold dissolve the crushed melt in 3 or 4 drops of cold water and filter off 2 drops with the filter tube onto a white spot plate. Place a drop of water in an adjacent impression of the plate, and add 2 drops of quinalizarin solution to both. A blue color imparted to the sample, readily distinguished from the blue-violet color of the blank, denotes the presence of beryllium.

MARKETS - Beryllium ore - Per ton, carload lots, minimum 10 percent BeO, $30; minimum 12 percent, $35, f.o.b. mines. Beryllium-copper - Master alloy, 4 percent beryllium, remainder copper, in lots 1 lb. or more of beryllium, $15 per lb of contained beryllium. (Quotations June 30, 1942).

POSSIBLE BUYERS

Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, N. Y.
Beryllium Corporation of Pennsylvania, Temple (near Reading), Pa.
Brush Beryllium Co., 3714 Chester Avenue, Cleveland, Ohio.
Foote Mineral Co., Inc., 1607 Summer St., Philadelphia, Pa.
A. B. Mackay, 198 Broadway, New York, N. Y.

BERYL (continued)

BIBLIOGRAPHY

George L. Gary. Notes on Beryl with a Quanlitative Analysis for Beryllium. Calif. State Mineralogists Report XXXVI (1940), pp. 86-95.
Adolf Pabst. Minerals of California. California State Division of Mines, Bulletin No. 113 (1938).
Alice V. Petar, Beryllium and Beryl. U.S.Bur. of Mines Inf. Circ. 6190 (1929).
Paul M. Tyler. Beryllium. Minerals Yearbook (1940), pp. 761-763.

NOTES:

1. Specimens of beryllium ore may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, Calif.

2. Other beryllium minerals are:- Chrysoberyl, phenakite, leucophane, meliphanite, helvite, euclase, gadolinite, beryllonite, herderite, bertrandite, danalite, eudidymite, hambergite, trimerite, bromellite, milarite, barylite, and kolbeckite. None of these minerals have been found in California with the exception of chrysoberyl, the occurrence of which is doubtful.

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | JANUARY - 1942 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

BISMUTH

By
George L. Gary, Mineral Technologist

PROPERTIES - Native bismuth (Bi) is usually reticulated, arborescent, foliated, or granular. It is brittle but when heated is somewhat malleable. Sectile. Luster metallic. Streak and color silver white with a reddish hue. Tarnish is dark brown. Hardness 2.5. Specific gravity 9.8.

BISMUTHINITE (Bismuth tri-sulfide Bi_2S_3, 81.2 per cent bismuth). It is usually massive with foliated or fibrous structure but also acicular, striated crystals. Luster metallic. Color and streak lead-gray. Hardness 2. Specific gravity 6.8.

Bismite or bismuth ocher is a hydrous bismuth oxide ($Bi_2O_3.3H_2O$) which commonly occurs as an earthy coating. The color is straw yellow.

Bismutite is of uncertain composition but is probably basic bismuth carbonate ($Bi_2O_3.CO_2H_2O$). It occurs as incrusting fibrous masses or earthy and pulverulent. The color is white, green yellow and gray. Hardness 4. Specific gravity 7.

OCCURRENCE - Native bismuth and bismuthinite are primary minerals but bismite is of secondary origin and results from the oxidation of other bismuth minerals. In California bismuth minerals have been noted in Fresno, Inyo, Madera, Mono, Nevada, Riverside, San Bernardino, San Diego, and Tuolumne counties.

PREPARATION - Bismuth ores, after a preliminary concentration, may be further treated either by wet or dry methods. By wet methods, bismuth is recovered from chloride solutions. However, smelting is a less wasteful process and is more widely used.

USES - Most of the bismuth produced is consumed in the preparation of medicinal salts. It is also a constituent of low melting-point alloys which are used for plugs in automatic sprinkler systems and for electric fuses, etc. The low melting-point and non-shrinking bismuth alloys are used in such national defense industries as the manufacture of machine tools and dies, aircraft and automobiles.

BISMUTH (continued)

TESTS - Bismuth may be distinguished from lead by fusion on charcoal with a mixture of potassium iodide and sulfur. A sublimate is formed which is yellow next to the mineral and brilliant red farther away. Lead gives a solid yellow coating under similar conditions. When heated on charcoal in the reducing flame with sodium carbonate, bismuth minerals yield a metallic globule and an oxide coating. The metal is easily fusible. It is lead gray when hot but becomes coated with bismuth oxide on cooling. It is only imperfectly malleable, for when hammered out it flattens at first but later breaks into small grains.

MARKETS - Per lb. in ton lots $1.25. (Quotations Jan. 1, 1942.)

POSSIBLE BUYERS

Baker, J. T., Chemical Co., Phillipsburg, N. J.
Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, N. Y.
Cerro de Pasco Copper Corp., 44 Wall Street, New York, N. Y.
Mann, F. J., Inc., 10-34 45 Rd., Long Island City, N. Y.
Merck & Co., Inc., Rahway, N. J.
Metallurgical Products Co., 35th & Moore Sts., Philadelphia, Pa.

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Franke, Herbert A., Minerals Yearbook Review of 1940. U. S. Bureau of Mines 1941.
Pabst, Adolf, Minerals of California, Bulletin 113, California State Division of Mines 1938.
Symons, Henry H., California Mineral Production for 1939, Bulletin 119, California State Division of Mines, 1940.
Tyler, Paul M., Bismuth. Information Circular 6466, July 1931. U. S. Bureau of Mines.

NOTES

Bismuth minerals may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

JULY - 1941

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

BORATES

By
George L. Gary, Mineral Technologist

PROPERTIES - Borax, $Na_2B_4O_7.10H_2O$, ulexite, $NaCaB_5O_9.8H_2O$, colemanite, $Ca_2B_6O_{11}.5H_2O$, kernite, $Na_2B_4O_7.4H_2O$ and probertite, $NaCaB_5O_9.5H_2O$ have successively been used as the chief source of borax and boric acid. Their physical properties are described as follows:

Name	Color	Luster	Hardness	Gravity
Borax	Colorless	Vitreous	2 - 2½	1.69 - 1.72
Ulexite	White	Silky	1	1.65
Colemanite	Colorless	Vitreous	4 - 4½	2.42
Kernite	Colorless	Vitreous	3	1.95
Probertite	Colorless	Vitreous	2½ - 3½	2.14

OCCURRENCE - The borate minerals are formed by the evaporation of bodies of salt water and as an efflorescence on the surface of the ground in arid regions. Borax was first discovered in California in the waters of Tuscan Springs in the northern part of Tehama County, about eight miles east of Red Bluff, in January 1856. Borax Lake in Lake County was discovered in September of the same year. This deposit was worked in 1864-68, inclusive, and during that time produced 1,181,365 pounds of refined borax. The bulk of it was exported by sea to New York. This was the first commercial output of this salt in the United States, and California is still to-day the leading American producer of borax, having been for many years the sole producer. Production from the dry lake deposits of Inyo and San Bernardino counties began in 1873; but it was not until 1887 that the borax industry was revolutionized by the discovery of the colemanite beds at Calico, in San Bernardino County and later similar beds in Inyo and Los Angeles counties. The colemanite deposits of Ventura County were not worked extensively, owing to lack of transportation facilities. Colemanite was in turn, displaced by the discovery in 1926 of kernite, about 7 miles northwest of Kramer, in Kern County. This is the only locality at which kernite is found and here associated with borax, ulexite, colemanite and proberite in a bedded series of Tertiary clays it is present by the million tons.

BORATES (Continued)

This deposit of sodium borates is in an area 4 miles long and 1 mile wide, and lies from 300 to 900 feet beneath the surface. The kernite is believed to have formed from borax by recrystallization caused by increased temperature and pressure. The 20-mule teams, with their load of borates from Death Valley to Mojave, formerly passed almost over these immensely more valuable buried deposits. The brines of Searles Lake are likewise an important source. Borates have also been found in El Dorado, Marin and Riverside counties, but not in commercial amounts.

PREPARATION - The process used for the refining of borates is essentially one of solution and evaporation followed by fractional crystallization.

USES - Borax has many uses which depend on its easy solubility in water yielding an antiseptic solution, its low melting point, and its superior fluxing properties. Some of the common uses of borax and boric acid are in medicine, food preservatives, disinfectants, deodorants, soaps and soap powders. Borax is of considerable industrial importance as a solvent of casein and is thus used in the manufacture of coated paper, plywood, plaster, paint and calcimine. It is an essential constituent of porcelain enamels used in coating iron and in the manufacture of tile and sanitary ware. It is used in the manufacture of heat-resisting glass and as a flux in welding and soldering operations.

TESTS - The borates are easily distinguished by their physical properties and taste. When heated they fuse easily and impart a yellow color to the flame. They are readily soluble in water and dilute hydrochloric acid. Turmeric paper, when moistened with the solution and dried, assumes a reddish-brown color. Most borate powder on platinum wire, moistened with sulfuric acid, will give a momentary green flame of boron.

MARKETS

Borax - Per ton, granular, contract, in bags $48; in barrels, $51. (Quotations June, 1941)

POSSIBLE BUYERS

American Cyanamid & Chemical Corp., 30 Rockefeller Plaza, New York, N. Y.
American Potash & Chemical Corp., 70 Pine St., New York, N. Y.
Borax Union (Div. Stauffer Chemical Co.), 624 California St., San Francisco, Calif.
John A. Chew, Incorporated, 60 East 42nd St., New York, N. Y.
E. I. du Pont de Nemours & Co., Inc., (The R. & H. Chemicals Department), Wilmington, Del.
General Chemical Co., 40 Rector St., New York, N. Y.
William S. Gray & Co., 342 Madison Ave., New York, N. Y.

BORATE (Con't'nued)

It is usually of sodium borates in an area 4 miles long and 1 mile wide, and lies from 300 to 500 feet above the surface. The borate is believed to have formed from borax deposited by evaporated temperature and pressure. The ulexite, with their sand of borates from Death Valley to Colony, formerly posted almost over this to immensely more valuable buried deposits. The buried 35 beds lies are likewise an important source. Torates have also been found in 34 borates, Marie in minerals ornatus, but not in commercial amounts.

PREPARATION - The process used for the refining of borates is essentially one of solution and evaporation followed by fractional crystallization.

USES - Borax has many uses which depend on its easy solubility in water, yielding an antiseptic solution, its low melting point, and its superior fluxing properties. Some of the common uses of borax and boric acid are in medicines, food preservatives, disinfectants, deodorants, toxon and soap powders. Borax is of considerable industrial importance as a solvent in certain ores in this used in the manufacture of enamel paper, glazes, glasses, paint and coatings. It is an essential constituent of porcelain enamels used in coating iron and in the manufacture of silk and sanitary ware. It is used in the manufacture of borosilicate glass and in flux in welding and soldering operations.

TESTS - The borates are readily distinguished by their physical properties and tests. When heated over Tirro colorless and fuses to glassy coins to the loop. They are readily soluble in water and dilute hydrochloric acid. Turmeric paper, when moistened with the solution and dried, assumes a reddish-brown color. Most borate powder in platinum wire, moistened with sulfuric acid, will give a characteristic green line of boron.

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(Quotation dues, Free)

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American Chemical & Chemical Corp., 30 Rockefeller Plaza, New York.

American Potash & Chemical Corp., 70 Pine St., New York, N. Y.
Borax Union (Div. Borax Consolidated Ltd.), 624 California St., San Francisco, Calif.
Coast A. Chew, Incorporated, 60 East 42nd St., New York, N. Y.
E. I. du Pont de Nemours & Co., Inc., (The H. K. Mulford Co.
Department), Philadelphia, Pa.
Garfield Chemical Corp., 40 Rector St., New York, N. Y.
William S. Dow & Co., 340 Madison Ave., New York, N. Y.

BORATES (Continued)

E. & F. King & Co., Inc., 405 Atlantic Ave., Boston, Mass.
Pacific Coast Borax Co., 51 Madison Ave., New York, N. Y.
Prior Chemical Corporation, 420 Lexington Ave., New York, N. Y.
Stauffer Chemical Co., Inc., 420 Lexington Ave., New York, N. Y.
Joseph Turner & Co., Ridgefield, N. J.
The Vitro Manufacturing Co., Corliss Station, Pittsburgh, Pa.
Welch, Holme & Clark, Inc., 563 Greenwich St., New York, N. Y.
Wilson & Geo. Meyer & Co., 601 Federal Reserve Bank Bldg., San Francisco, Calif.

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Waldemar T. Schaller. Borax and Borates. Industrial Minerals and Rocks. The American Institute of Mining and Metallurgical Engineers. New York. (1937) pp. 149-162.
Paul M. Tyler and A. T. Coons. Borates. Minerals Yearbook, 1940, pp. 1448-1449.

NOTES

1. Specimens of borate minerals may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Ludwigite, vonsenite, camsellite, howlite, bakerite, veatchite, meyerhofferite, inyoite, priceite, tincalconite, hydroboracite and teepleite are borate minerals found in California but not as yet in commercial amounts.

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Pfizer Chemical Corporation, 630 Greenwich Ave., New York, N.Y.
Stauffer Chemical Co., Inc., 420 Lexington Ave., New York, N.Y.
Thomas Thomas & Co., Alhambra, Cal.
The Tuttle Development Co., Central Station, Westchester, Pa.
Union & Comm. Inc., 149 Greenwich St., New York, N.Y.
Western Salt Co., 351 California St., San Francisco, Cal.
Wilson & Geo. Meyer & Co., 601 Howard Street, San Francisco, Cal.
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Paul M. Tyler and L. L. Green. Borates. Industrial Minerals and Rocks. (1949). pp. 1-22, 1940.

NOTES

In Searles Lake minerals may be seen in the mines, stores of the California Trona Division of Stauffer Chemical Co., Trona, California.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | JANUARY - 1942 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

CADMIUM

By
George L. Gary, Mineral Technologist

PROPERTIES - Greenockite is the only cadmium mineral so far discovered in California. It is cadmium sulfide (CdS, 77.8 per cent cadmium) which is found as pulverulent or powdery incrustations and sometimes as small hexagonal crystals, usually as a coating on sphalerite.

The luster is resinous or earthy and the color is yellow or orange. Streak is between orange-yellow and a brick-red. Hardness 3½. Specific gravity 4.9.

OCCURRENCE - Greenockite has been found in Inyo, Mono, Riverside, and Shasta counties. The only recorded production of cadmium in California was in 1917-1918 from the electrolytic zinc plant of the Mammoth Copper Company in Shasta County.

Greenockite in the Cerro Gordo mines, Inyo County, occurs with smithsonite (zinc carbonate).

PREPARATION - The sources of cadmium that have been utilized are zinc ores containing small amounts of cadmium treated by fractional distillation, lead furnace bag-house "fumes", and residues from the purification vats of electrolytic zinc plants.

The recovery of cadmium by the fractional distillation of zinc ores depends on the fact that cadmium volatilizes more readily than zinc. The first vapor to distill off is collected as a powder and contains more cadmium than that going over later. The powder is refined to recover the cadmium. Practically all lead ores carry some zinc which in turn contains a small percentage of cadmium. This small amount of cadmium collects as dust in the bag-house where it is allowed to accumulate until a sufficient amount is present to warrant recovery.

USES - Cadmium metal is used in making alloys with low melting points. A cadmium-copper alloy wire is about 50 per cent stronger than pure copper wire and the conductivity is decreased only 10 per cent. Cadmium may be substituted for tin in solder. Cadmium, when electroplated on metal articles, may be alloyed with the metal by heating to a moderate temperature. Cadmium sulfide ia used as a pigment in paints and glass ware.

Walter W. Perry
Chief Mineralogist

Texas Natural Resources
Austin, Texas

COMMERCIAL MINERALS OF CHEMICOMIA
(Series 1952)

CHROMITE

By
George B. Gray, Assistant Technologist

PROPERTIES - Chromite is the only ore of chromium mined in the Chemicomia district. It is a cubic mineral (C.G. 4.6, Y&A 5½ per cent chromium) which is found as pulverulent or pebbly disseminations and nodules as small rounded aggregates, usually in a matrix of [illegible].

The luster is resinous or earthy and the color is yellow or orange. Chromic ion imparts a green-yellow cast to [illegible]. It occurs in [illegible].

OCCURRENCE - Great pockets had been found in Long Mine, Mount Pride, and Quartz Mountain. The only recorded production of chromite in Chemicomia was in 1947-1948 from the Chromatown mine at a point 10 miles due [illegible] the Harmon Copper Company in Sweetwater County.

Chromatite is the Cerro Verde mines, Cerro Verde County, occurs with [illegible] (also chromite).

PREPARATION - The average of chromium ores mined must [illegible] ore [illegible] small amount of chromic oxide by [illegible] crystallization, [illegible] "grunch", and washing iron, the [illegible] vein of chromite, also Olmito.

The recovery of chromium by the fractional [illegible] of [illegible] chromite on the least that sodium volatilizes more readily than [illegible]. The first vapor to distill off is collected as a [illegible] and [illegible] more chromium than [illegible]. The [illegible] is purified to recover the chromium. Theoretically [illegible] zone which is then converted a small percentage of chromium. This small amount of chromium obtained is then [illegible] allowed to accumulate until a sufficient chromic [illegible] recovery.

USES - Chromium metal is used in making alloys with [illegible] powder. A ferrochrome alloy with 50 per cent chromium [illegible] plate either by [illegible] be deposited only 10 per cent. Chromium may be [illegible] in solvent. Chromium [illegible] electrolysis on local artifacts may be alloyed with [illegible] mounting to a [illegible] appearance. Chromium [illegible] is used in [illegible] fibers [illegible].

CADMIUM (continued)

TESTS - On charcoal with soda, compounds of cadmium give a characteristic sublimate of the reddish brown oxide; on plaster the coating is yellowish green with brown.

MARKETS - Per lb. commercial sticks, wholesale quantities, 90c. (Quotation November 20, 1941).

POSSIBLE BUYERS

American Smelting & Refining Co., 120 Broadway, New York, N.Y.
American Zinc Sales Co., P.O.Box 327, Columbus, Ohio.
Associated Metals & Minerals Corp., 40 Rector St., New York, N.Y.
Ayrton Metal Company, Inc., 11 Broadway, New York, N. Y.
Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, N. Y.
Donald Sales & Mfg. Co., 2546 W. Greves St., Milwaukee, Wis.
Du Pont de Nemours, E.I. & Co., Inc., (Electro-plating Division), Wilmington, Del.
European Chemical & Metal Co., 366 Broadway, New York, N.Y.
Henning Bros. & Smith Inc., 24 Venderbilt Ave., Brooklyn, N. Y.
Industrial Sales Corporation, 295 Madison Ave., New York, N. Y.
The Laxseed Company, Inc., 625 West 55th St., New York, N. Y.
Mercantile Metal & Ore Corp., 67 Broad St., New York, N. Y.
Metallurgical Products Co., 35th & Moore Sts., Philadelphia, Pa.
National Zinc Co., Inc., Bartlosville, Okla.
Philipp Brothers, Inc., 70 Pine Street, New York, N. Y.
St. Joseph Lead Co., 250 Park Ave., New York, N. Y.
U. S. Smelting, Refining & Mining Co., 57 William St., New York, N.Y.

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NOTES

1. Specimens of cadmium may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Other cadmium minerals are cadmiumoxide (CdO) and otavite & cadmium carbonate.

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Bibliography (continued)

State of California
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DIVISION OF MINES

Walter W. Bradley State Mineralogist	JUNE - 1942	Ferry Building San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

CHROMITE

By
George L. Gary, Mineral Technologist

PROPERTIES - Chromite is an oxide of chromium and iron, $FeO.Cr_2O_3$. When pure it contains 68% Cr_2O_3 and 32% FeO. It shows considerable variation in composition and rarely conforms to the theoretical formula. The iron may be replaced by magnesium; also the chromium by aluminum and ferric iron. It is a black, massive, fine granular to compact mineral. It is brittle and occurs with an uneven fracture. The hardness is 5.5 and the specific gravity varies from 4.1 to 4.9.

OCCURRENCE - Chromite is widely distributed in California, the principal production, thus far, having come from El Dorado, San Luis Obispo, Del Norte, Shasta, Siskiyou, Placer, Fresno, and Tuolumne counties. A total of 30 counties have contributed to the State's output. There are two main belts in California yielding this mineral, one along the Coast Ranges from San Luis Obispo County to the Oregon line, including the Klamath Mountains at the north end, and the other in the Sierra Nevada from Tulare County to Plumas County. Chromite occurs as lenses in basic igneous rocks such as peridotite and pyroxenite, and in serpentines which have been derived by alteration of such basic rocks. Frequently residual deposits occur, as it is highly resistant to atmospheric influences, and it is, therefore, common in gravels.

PREPARATION - Most chromite is mined from quarries or open pits, although there are some underground operations. The ore is usually shipped in the condition in which it is mined, however, there are concentration plants in California from which shipments of concentrates are made. Chromite containing around 40% Cr_2O_3 is made into bricks slightly larger than the ordinary building bricks and used directly as refractory lining. Ferrochromium, used in the manufacture of steel, is made in the electric furnace. The chromite is mixed with coal and shoveled into the furnace around the electrodes. Reduction takes place and the alloy is tapped from the bottom of the furnace into iron receivers. The charging is continuous so that the top of the mix remains unfused. The alloy contains from 60% to 65% chromium and from 5% to 9% carbon. Chromite containing 48% to 50% Cr_2O_3 is the ore generally used for the production of ferrochromium.

CHROMITE (continued)

USES - According to the Minerals Yearbook, 1938, about 50 per cent of the application of chromite is in the manufacture of ferrochromium, the alloy used in making chromium steel. The chromium content in average chrome steel is approximately 2 per cent. This class of steel absorbs the largest tonnage of chromium used in the steel industry. Chromium alloys are extremely hard and tough but can be bent while cold or welded to iron to form either a hard surface or a core virtually impenetrable to the finest drilling tools. Steel containing either chromium alone or chromium alloyed with such metals as nickel, vanadium, tungsten, and manganese are used for armor plate, armor-piercing projectile, and machinery subjected to abrasive action. Steels containing 5 to 6 per cent chromium have been advertised as nonrusting. Steel known commercially as "rustless" contain 13 to 18 per cent chromium. These are said to be noncorrosive in the presence of water, air, and certain acids. This alloy is used extensively in the manufacture of exhaust valves, turbine blades, pump rods, rollers for bearings, electric heating stoves, and cooking utensils.

Alloys of chromium, cobalt, tungsten, or molybdenum are known as "stellite" and are employed largely for high-speed tool steel. These metals impart to steel the ability to retain their hardness and cutting edge at high temperatures when run at speeds at which ordinary carbon tool steel would soften owing to heat caused by friction. Chromium is used extensively in the plating industry. The surface is hard and white, is resistant to the action of ammonia fumes, hydrogen sulphide, and nitric acid, and is not attacked by molten zinc, tin, or brass.

About 40 percent of the consumption of chroiite is in the manufacture of refractories used as a lining for furnaces. The utilization of chromite in the form of bricks and special shapes is not a necessity but has come into general use because the bricks do not soften readily in the heat of the furnaces and contaminate the melts. As the qualities of the metal chromium become better known in industry, consumption of the mineral chromite for refractory purposes may be curtailed. The chromite used for refractory purposes is dissipated and rendered unrecoverable after a limited period. On the other hand, chromite steels may be reclaimed and used until actual dissipation by abrasion is completed.

Chromite is of great importance to the chemical industry. From it is obtained the chromium used for making chromates and bichromates. Chrome pigments--yellow, green, and red-- are widely used. In the dye industry, the soluble chromates and buchromates are used as mordants. Chromates are also used in tanning chrome leather and in bleaching fats and oils. In the ceramic industry chromic acid and buchromates are used to color pottery.

In the manufacture of chrome alloy steel, ferrochromium is invariably employed. The use of chrome for the manufacture of projectiles, armor plate, rifle linings, high-speed tool steel, automobile axles and springs, locomotive frames and springs, and in general where steel parts must stand hard usage, indicates its importance from a military standpoint.

CHROMITE (continued)

TESTS - Chromite before the blow-pipe in the oxidizing flame is infusible; in the reducing flame it is slightly rounded on the edges and becomes magnetic. With borax and salt of phosphorous a little of the powder of the mineral containing chromium gives beads which on cooling, are of bottle-green color. It is not acted upon by acids, but decomposed by fusion with potassium or sodium bisulphate.

MARKETS - Chrome ore, per ton at domestic mines, 45%, Cr_2O_3, $40.50 in carload lots (Quotations February 1942) (4).

POSSIBLE BUYERS

Ansbacher-Siegle Corporation, Rosebank, S. I. N. Y.
Bethlehem Steel Co., 20th & Illinois Sts., San Francisco, California.
Bradley & Ekstrom, 320 Market Street, San Francisco, California
Columbia Steel Co., Russ Building, San Francisco, California
Charles Cooper & Co., 6 Mulberry Street, New York, N. Y.
Stanley Doggett, Inc., 75 Varick Street, New York, N. Y.
B. F. Drakenfeld & Co. Inc., 45 Park Place, New York, N. Y.
Fernandie & Sperrle, Inc., 205 Fulton St., New York, N. Y.
Foote Mineral Co., 1607 Summer St., Philadelphia, Pa.
General Chemical Co., 440 Sansome Street, San Francisco, California.
International Selling Corp., 67 Broad Street, New York, N. Y.
Metals Reserve Co., Washington, D. C.
Ohio Ferro Alloys Corp., Tacoma, Washington.
Ore Metals & Engineering Corp., 112 Market Street, San Francisco, Calif.
Henry Rising & Co., 626 St. Paul Avenue, Los Angeles, California
Rustless Mining Corp., 924-22nd St. Sacramento, California.
Smith Chemical & Color Co., 55 John St., Brooklyn, N. Y.
J. Lee Smith & Co., Inc., 23 Jacob Street, New York, N. Y.
U. S. Vanadium Corp., 114 Sansome Street, San Francisco, California
Vance & Barnes, Ltd., 1131 Park Avenue, Alameda, California
Vitrefrax Corp., P.O.Box 308, Vernon Branch, Los Angeles, California
Charles A. Wagner Co., Inc., 815 Callowhill St., Philadelphia, Pa.
A. H. Wild, U. S. Chrome Mines, Inc., Russ Building, San Francisco, Cal
Wishnick-Tumpeer, Inc., 295 Madison Ave., New York, N. Y.

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Leonid Eryssen: A Study of the Chromite Resources of California. California State Division of Mines (unpublished thesis).
J.S. Diller, L. G. Westgate and J. T. Pardee: Deposits of Chromite in California, Oregon, Washington and Montana. U.S.Geological Survey Bulletin 725a (1922).
L. W. Fisher: Chromite--Its Mineral and Chemical Composition. American Mineralogist (October 1929) 14, 10.
R. B. Ladoo: Non-metallic Minerals, McGraw-Hill Book Co., New York, 1925.
R. H. Ridgway: Chromite. Minerals Yearbook, 1940. U.S.Bureau of Mines.
R. H. Ridgway: Shifts in Sources of Chromite Supply. U.S.Bureau of Mines Information Circular 6886 (1936).

CHROMITE (continued)

G. A. Rynearson and C. T. Smith: Chromite Deposits in the Seiad Quadrangle, Siskiyou County, California. U. S. Geol. Survey Bull. 922-J (1940)
E. Sampson: Varieties of Chromite Deposits. Econ. Geol. (1931) 26, 8.
L. A. Smith: Chromium, General Information. U. S. Bur. Mines Inf. Circ. 6566 (1931).
F. G. Wells, L. R. Page and H. L. James: Chromite Deposits of the Pilliken Area, El Dorado County, California. U. S. Geol.Survey Bull. 922-O (1940).

NOTES

1. Specimens of chromite may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. For the manufacture of certain steels there is no known substitute for chromium. In tanning, no satisfactory substitute has been found. Chromates for pigments may be replaced, but as a rule substitutes are more expensive. As a refractory, chromite competes commercially with and may be replaced by other materials.

3. There are eleven other chromium minerals found in California, but the mineral chromite is the only ORE of chromium.

4. Prices of chrome ores and specifications for different grades are changing monthly. The Division of Mines will be glad to furnish new prices and specifications upon request.

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | JANUARY - 1942 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

COBALT

By
George L. Gary, Mineral Technologist

PROPERTIES - Cobaltite (A sulfarsenide of cobalt, CoAsS, 35-4 per cent cobalt) commonly occurs in cubes with faces striated similar to those of pyrite. It is also granular or massive. The luster is metallic; color silver white with a reddish tint. Streak grayish black. Cleavage is cubic and the mineral is brittle. Hardness 5½. Specific gravity 6.3.

Smaltite (Cobalt diarsenide, $CoAs_2$, when pure. Cobalt 28.1 per cent). The mineral is usually massive or granular. It has a metallic luster and is tin white to silver gray in color with a black streak. Brittle. Hardness 5½. Specific gravity 6.5

Erythrite or cobalt bloom is a hydrous cobalt arsenate $Co_3As_2O_8.8H_2O$. It usually occurs as crusts in globular and reniform shapes but may also be pulverulent and earthy. The luster is adamantine to vitreous, pearly on cleavage. Color crimson to pink. Perfect cleavage at right angles to the length of the crystal. Hardness 1½ - 2½. Specific gravity 2.9.

OCCURRENCE - Most of the cobalt produced in North America is obtained from the nickel ores of Ontario, Canada.

In California, cobalt minerals have been found in Calaveras, Los Angeles, Mariposa, Mono, Napa, Nevada, Placer, and San Diego counties, but no commercial production has been recorded. The copper ores of Madera and Mariposa counties have been found to contain cobalt up to 3 per cent.

In general, cobalt minerals are intimately associated with ores of nickel, the most widely distributed of which is nickeliferous pyrrhotite.

PREPARATION - Arsenical ores, such as those from Cobalt, Ontario, are usually smelted in a blast furnace to form a speiss which is a mixed arsenide of iron, cobalt, and nickel. The speiss is roasted to remove the bulk of the arsenic and the residue, usually containing about 10 per cent aresnic and from 20 to 30 per cent cobalt, is treated by wet methods to separate the nickel and cobalt.

One chemical process for separating nickel from cobalt is to add calcium hypochlorite to a chlorite solution of cobalt (freed from arsenic, iron and copper) to precipitate cobalt hydroxide. (Nickel will precipitate if an excess of calcium hypochlorite is used). The cobalt hydroxide is then dried and calcined. The resulting product carries about 76 per cent cobalt.

USES - Cobalt metal is used in the stollite alloys which contain varying amounts of cobalt, chromium, tungsten, iron, and carbon, for cutting tools and drills. It is also used in welding rods, stock for tipping tools, dies, valve steel, magnets, electroplating, etc. It has been used to supplement pasture deficiencies that cause various types of sickness among animals.

Cobalt oxide is used in the ceramic industry. Cobalt salts are employed in the preparation of driers for use in paints, varnishes, and linoleums, and as catalysts.

TESTS - The borax or salt of phosphorus bead is dark blue in both the oxidizing and reducing flames when cobalt is present. Where sulfur or arsenic is present, the mineral should first be roasted on charcoal before testing for cobalt.

MARKETS - Per lb. 97 @ 99 per cent, $2.11 for small lots spot. On lots of 100 lbs. or more $1.50.

POSSIBLE BUYERS

Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, N. Y.
Central Trading Corp., 511 - 5th Ave., New York, N. Y.
International Selling Corp., 67 Broad St., New York, N. Y.
Marks & Co., Carl, Inc., 50 Broad St., New York, N. Y.

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Hess, Frank L. : Cobalt. Mineral Resources of the United States, Part I, 1917, U. S. Geological Survey.
Pabst, Adolf : Minerals of California, Bulletin 113, California State Division of Mines, 1938.
Riss, H. : Economic Geology. (Seventh Edition) John Wily & Sons, Inc., New York, London. Chapman and Hall Limited, 1937.
Tylor, Paul H. : Cobalt. Information Circular 6331, U. S. Bureau of Mines, August 1931.

NOTES

Specimens of cobalt minerals may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

COBALT (continued)

One chemical process for obtaining nickel from Sudbury is to mix sulphur dioxide gas with a chloride solution of cobalt (Cobalt Trade Journal, June 1940 issue) to precipitate cobalt hydroxide. (Nickel will remain in the solution.) Cobalt hydroxide is then dried and reduced. The resulting product contains about 75 per cent cobalt.

USES - Cobalt metal is used in the metallic alloys which comprise varying amounts of cobalt, chromium, tungsten, iron, and nickel, for cutting tools and drills. It is also used in welding rods, alloy steels, dies, heavy steel, magnets, electroplating, etc. It has been used in permanent magnet alloys (Alnico) and various types of stainless steel.

Cobalt oxide is used in the ceramic industry. Cobalt salts are employed in the preparation of driers for use in paints, varnishes and linoleum, and by dentists.

PRICES - The buyer or sole selling agent is most likely to deal in cobalt and refining firms whose names appear in the Canadian Mining Journal or Engineering and Mining Journal. Where quotations are given in pounds, the ordinary commercial unit is 100 lbs. or more.

MARKETS - Per lb. 97 @ 99 per cent, $1.13 for small lots of 100 lbs. or more $1.50.

PERIODICAL REFERENCE

National Smelting & Refining Monthly, Times, 3rd Saturday Ave., Monthly.
E. & M. J.
Cobalt Trading Corp., 111 - 5th Ave., New York, N. Y.
International Nickel Corp., 67 Broad St., New York, N. Y.
Metals & Co., Scrap, Inc., 50 Broad St., New York, N. Y.

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Hess, Frank L. : Cobalt, Mineral Resources of the United States, Part I, 1917, U. S. Geological Survey.
Penn, Arnold : Minerals in Industry, Pelican 113, Cobalt-Nickel Mines, Limited, 1938.
Rolf, R. : Economic Geology, Economic Geology Pub. Co., New Haven, Conn.
Taylor, Paul D. : Cobalt, Information Circular 6921, U. S. Bureau of Mines, August 1937.

NOTES

Specimens or exhibit showing ore in which is the source of the Canadian Cobalt Division of Mines, Mount Pleasant, New Brunswick, Ontario.

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

AUGUST - 1941

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

COPPER

By
George L. Gary, Mineral Technologist

PROPERTIES - Chalcopyrite, a copper and iron sulfide, $CuFeS_2$ is the most common and important ore of copper. It occurs usually in massive form. It is a brittle mineral and has a metallic luster. The streak is greenish-black and the color brass-yellow; often tarnished to bronze or iridescent. The hardness is 3½-4 and the specific gravity 4.1-4.3. There are other important copper-ore minerals which are noted at the end of this paper.

OCCURRENCE - Chalcopyrite is commonly of primary origin and from it, by various alteration processes, many other copper minerals are derived. It has been repeatedly observed as an original constituent of igneous rocks, and the ultimate source of copper of ore deposits is to be found in rocks of this type. Noted in pegmatite veins. It occurs widely in metallic veins and in nests in gneiss and crystalline schists, also in serpentine rocks. The deposits are frequently near igneous rocks. In contact metamorphic deposits; at times broadly disseminated in schistose rocks. Often intimately associated with pyrite, pyrrhotite, sphalerite, galena, quartz, dolomite, siderite, and various copper minerals. Chalcopyrite is the principal source of copper in California. The copper deposits are largely bodies of pyrite in which chalcopyrite is intermingled. Most of the deposits have a capping of earthy limonite and hematite resulting from the oxidation of the iron sulfides. Practically all of the large bodies of pyrite in the State carry some chalcopyrite, but those in Plumas, Shasta and Calaveras counties have been the most important in the production of copper.

PREPARATION - Copper ores are smelted in both blast and reverberatory furnaces. Iron oxide, limestone and silica are used as fluxes and coke is the fuel commonly used in blast furnaces, while various cheaper fuels may be used in reverberatory furnaces. In the blast furnace the charge is introduced through a door at the top and consists of alternate layers of coke and ore, the latter being mixed with fluxing materials. The proper proportion of fluxing materials is calculated from the composition of the particular ore to be treated. Combustion is maintained by blasts of hot air through openings, called 'tuyeres' near the bottom of the furnace.

-4-

COPPER (Continued)

As the charge is melted to a fluid condition, the metals settle to the bottom of the furnace and are drawn off in the form of 'matte.' This is a mixture of sulfides, principally copper and iron, and generally contains gold and silver values. The fluxes combined with the gangue minerals to form 'slag' which remains above the 'matte,' and is drawn off at intervals. The process is a continuous one, new charges being added at regular intervals. In some sulfide ores containing a high percentage of sulfur a preliminary roasting process is necessary to eliminate some of the sulfur. In the reverberatory furnace the fire box is separated from the charge by a low partition and the heat is carried directly over the surface of the mixed ore and flux by a draught. This furnace is particularly adapted for smelting fine ore and is used in localities where fuel is cheap. The capacity is not usually as great as that of the blast furnace and the removal of the 'matte' and 'slag' and recharging operations necessitate delays. The molten 'matte' resulting from either of the above smelting methods, is drawn off into steel ladels and transferred, generally by means of electric cranes to the converters. These converters are steel, bowl-shape vessels from ten to twenty feet in diameter and mounted so that they may be tipped to receive the 'matte' or to discharge the finished product. By means of air blasts, through 'tuyeres' at the bottom of the converters, the charge of 'matte' is oxidized to 'blister copper' which contains about 75% copper. Blister copper may also be produced from the matte by a series of roasting operations in reverberatory furnaces. The 'blister copper' is finally refined to pure metallic copper, the most modern method being by electrolysis. A preliminary refining treatment is often given the 'blister' in a reverberatory refining furnace. In the final electrolytic refining operation the associated gold, silver, platinum and other precious and rare metals are recovered. In electrolytic refining the blister copper is first melted and cast into anodes. By electrolysis, cathode copper 99.98% pure is deposited. These cathodes are melted and cast into the various commercial shapes. The wet method of treating or leaching is used on carbonate or oxidized copper ores. The leaching solution is generally dilute sulfuric acid and the copper is precipitated electrolytically as cathode copper or as cement copper, precipitated on scrap iron. Many low-grade sulfide ores are now being concentrated by means of oil flotation.

USES - Copper is second only to iron as a metal essential to modern civilization, and thus has many uses. Its greatest use is for electrical purposes, mostly as wire. It is extensively used in the form of sheets and nails. It has important uses in various alloys, as brass (copper and zinc), bronze and bell metal (copper and tin, and in some cases zinc, also), German silver (copper, zinc and nickel), Copper sulfate, or blue vitriol, is used in calico printing and in galvanic cells.

TESTS - On charcoal, at least with soda, metallic copper can be reduced from most of its compounds. In the case of sulfides the powdered mineral should be roasted first in order to eliminate the major part of the sulfur before fusion with soda. With borax it

gives (oxidizing flame) a green bead when hot, becoming blue when cold; also (reducing flame), if saturated, an opaque red bead containing Cu_2O and often Cu is obtained. Copper chloride, obtained by moistening the mineral with hydrochloric acid (in the case of sulfides the mineral should be previously roasted) yields a vivid azure-blue flame; copper oxide gives a green flame. Most metallic compounds are soluble in nitric acid. Ammonia in excess produces an intense blue color in the solution.

MARKETS - Domestic copper f.o.b. refinery, 11.833¢; export copper, f.o.b. refinery 10.950¢. (Quotations July 31, 1941.)

POSSIBLE BUYERS

American Smelting and Refining Co., Tacoma, Washington.
American Smelting and Refining Co., Garfield, Utah.
Anaconda Copper Mining Co., Anaconda, Mont.
Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, N. Y.
E. I. du Pont de Nemours & Co., Inc., (Electroplating Division), Wilmington, Del.
International Smelting and Refining Co., Miami, Ariz. and Tooele, Utah.
Kennecott Copper Corp., McGill, Nevada
Kennecott Copper Corp., 120 Broadway, New York, N. Y.
Los Angeles Chamical Co., 1960 Santa Fe Ave., Los Angeles, Calif.
Mountain Copper Co., Ltd., 351 California St., San Francisco, Calif.
Phelps Dodge Corp., Douglas, Clifton & Clarkdale, Ariz.
Phelps Dodge Refining Co., 40 Wall Street, New York, N. Y.
Tennessee Copper Co., 61 Broadway, New York, N. Y.

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A. Hausmann, J. Kruttschnitt, Jr., W. E. Thorn and J. A. Edman. The Copper Resources of California. California State Division of Mines Bulletin No.50 (1908).
H. M. Meyer. Copper. Minerals Yearbook (1940), p. 73-106.
Adolf Pabst. Minerals of California. California State Division of Mines, Bulletin No.113. (1938).

NOTES

1. Specimens of copper ores, may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Native copper, Cu, chalcocite, Cu_2S, bornite, Cu_5FeS_4, covellite, CuS, tetrahedrite, $(Cu,Fe,Zn,Ag)_{12}Sb_4S_{13}$, enargite, Cu_3AsS_4, cuprite, Cu_2O, atacamite, $Cu_2Cl(OH)_3$, malachite, $Cu_2CO_3(OH)_2$, azurite, $Cu_3(CO_3)_2(OH)_2$, antlerite, $Cu_3(SO_4)(OH)_4$, chalcanthite, $CuSO_4.5H_2O$, and chrysocolla, $CuSiO_3.2H_2O$ are all copper minerals which in some localities are the principal ores of copper.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

MARCH - 1942

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

DIAMONDS AND GRAPHITE

By
George L. Gary, Mineral Technologist

Except for their chemical composition, diamonds and graphite have very little in common. They are considered together here in order to conserve space.

PROPERTIES - The diamond is a form of pure carbon (C) which commonly crystallizes as octahedrons of the isometric system. The edges and faces of the crystals are usually striated or pitted. The luster is adamantine on cleavage faces. Uncut crystals have a characteristic greasy appearance. It ranges in color from colorless or pale yellow to pale red, orange, green, blue, or brown. The cleavage is perfect octahedral. Hardness 10 (This is the hardest mineral known). The specific gravity of the pure crystallized mineral is 3.52, but according to the variety, it may range from 3.51 to 3.53.

Bort is a dark, translucent to opaque, poorly crystallized diamond which often possesses a radial fibrous structure. Diamond crystals and fragments of inferior quality unfit for gems are also called bort.

Ballas is the name given to spherical masses of minute diamond crystals which are arranged more or less concentrically. These masses do not cleave easily due to the structure.

Carbonado, also known as black diamond or carbon is an opaque, black or gray, tough and compact variety which has no cleavage. The specific gravity ranges from 3.15 to 3.29.

Graphite is the hexagonal form of carbon (C) and usually occurs in foliated or scaly masses, although it is occasionally found in six-sided (hexagonal) tabular crystals. The perfect cleavage in one direction accounts for its platy structure. The luster is metallic to dull or earthy. Color, black to steel gray. Hardness 1-2. Specific gravity 2.3.

OCCURRENCE. Diamonds in California have been found only in placer gravels and in the black sands and concentrates of placer mines. Presumably their origin was in basic igneous rocks from which the serpentine of the gold regions were derived.

California localities that have produced diamonds are Volcano, Amador County; Cherokee, Morris Ravine, and Yankee Hill, Butte County;

Placerville and Smith's Flat, El Dorado County; Gopher Hill and Upper Spanish Creek, Plumas County.

At Kimberley, South Africa, diamonds occur in a dark greenish, basic igneous rock known as kimberlite. This is the world's chief source of supply.

GRAPHITE may be found in igneous, sedimentary, or metamorphic rocks. It most often occurs in metamorphic rocks such as schists, gneisses, and metamorphosed limestone.

Extensive deposits of good quality graphite are not known in California, but there are a few small deposits from which material suitable for paints and roofing material could be mined.

The only recorded production since 1931 has come from Los Angeles County. As a constituent of metamorphic rocks, graphite may be found in varying amounts in every county in the State.

PREPARATION - Due to the relatively high specific gravity of diamonds, they may be removed from gravel, clay, etc., by gravity methods.

At the Kimberley mines in South Africa, the "blue ground" or kimberlite is crushed, washed, and concentrated. The concentrate is then passed over a "greaser" or automatic diamond sorter which is designed to take advantage of the fact that diamonds stick more tenaciously to grease than any of the other non-metallic minerals. The recovery is practically 100 percent if the tailings from the first separation are passed over a greaser again before being discarded.

For graphite, the character of the material and its intended use determine the method of beneficiation. Some uses such as for foundry facings and paints require only grinding of the graphite, whereas flake graphite, which usually occurs disseminated, must be separated from its containing rock by crushing and grinding, followed by some means of concentration such as flotation. Further refining to remove small pieces of silica and other impurities from between the flakes, is often necessary to get a pure product. This is essentially true if the material is to be used as a lubricant.

USES - Diamonds of gem quality are differentiated according to color into ten or more different classes, the most valuable of which is blue. The familiar blue-white diamond (known as top crystal) which actually shows no tinge of blue, ranks fourth in the list, being superseded by Jaeger and Wessleton qualities or grade. The yellow or brown diamonds are ninth and tenth in the classification (see Kraus and Slawson - Gems and Gem Materials, for a more complete discussion of the grade of diamonds).

Powdered bort is employed in polishing diamonds. Selected bort, in whole crystals, of uniform grade and size, is used in diamond-set rock drill bits. Dies for drawing fine wire, tools for glass cutting, stone cutting etc., are made of diamonds unsuited for gem purposes, that is, off color stones which are free from flaws.

Ballas, due to its toughness and lack of cleavage, is well adapted for industrial purposes.

Carbonado is used in diamond-set rock drills and in diamond-set lathe tools which are in turn used for truing abrasive wheels.

KIMBERLEY AND VICINITY
(continued)

Diamond Jubilee and Dutoitspan Roads, Old Dorstone Country Clubs, Upper Queen Street, Flower Country.

At Kimberley, South Africa, diamonds rescue it from financial decline. Gold doesn't rank among its attractions. This is the world's center of diamonds.

CHARACTER may be found in surface, sedimentary or metamorphic rocks. It more often occurs in metamorphic rocks than in sedimentary, igneous, and metamorphosed limestone.

Stimulative response of good quality products and services known by CHARACTER, but there are few small companies whose names are universally recognized for their CHARACTER.

The only recorded indication since 1931 has been from Angelica County. An unconfirmed report of metamorphic rocks, possibly may be found in nearby counties in any county in the State.

FLUORITE - Due to its relatively high specific gravity of [illegible] they are usually found [illegible] or gravity [illegible]

At the Kimberley mines in South Africa, one [illegible] by [illegible] the [illegible] [illegible] conveyors. The conveyors [illegible] [illegible] [illegible]

Graphite, finely ground and mixed with varying amounts of high grade clay is molded and baked to be used as "lead" in pencils.

Perhaps the most important use of graphite at present is as a lubricant for heavy machinery.

Graphite crucibles are used for melting brass and for other small scale metallurgical operations.

The lower grades of graphite without oxidizable impurities are suitable for paints. The so-called "amorphous" graphite (which is composed of extremely fine crystalline grains but has a dull earthy appearance) is used for foundry facings.

Because of its electrical conductivity, graphite is valuable for electrodes, brushes in motors, etc., although the artificial product offers strong competition to the natural material.

TESTS - Diamonds may be recognized by their extreme hardness, striations on the crystal edges and faces, perfect octahedral cleavage, relatively high specific gravity, and by the greasy appearance of the uncut material and adamantine luster on the cleavage faces. They are insoluble in acids and alkalies.

Graphite in minute isolated specks may be difficult to distinguish but larger pieces are characterized by their softness, slippery feel, black color and streak on glazed paper or porcelain. It is infusible, insoluble and of relatively low specific gravity for a mineral with metallic luster.

MARKETS - During 1940 the average of imported industrial diamonds was about $3.50 per carat and ranged from $1.00 to $30.00 per carat. The price of uncut diamonds of gem quality varies according to size, shape and quality and ranges from $5.00 to $50.00 per carat (The term "quality" in the diamond industry means color or lack of it, and freedom from flaws or inperfections in the gem stones).

For first grade cut diamonds, the current 1942 price is around $500. per carat.

POSSIBLE BUYERS OF DIAMONDS (Industrial)

Crafts Diamond Tool Corp., Boston, Mass.
Dessan Co., Maurice S., 6 Maiden Lane, New York, N. Y.
Diamond Drill Carbon Co., New York, N. Y.
Karelsen Inc., E., 56 West 45th St., New York, N. Y.
Norton Co., Worcester, Mass.
Smith & Sons, J.K., Inc., 157 Chambers St., New York, N. Y.
Sperisen, Francis J., 166 Geary Street, San Francisco, California.
Standard Diamond Tool Corp., 64 West 48th Street, New York, N. Y.

POSSIBLE BUYERS OF DIAMONDS (Gem)

Fine & Sons, Inc. Max, 20 West 47th Street, New York, N. Y.
Kahn & Co. L. & M. , 608 Fifth Avenue, New York, N. Y.
Roselaar, Louis A., 551 Fifth Avenue, New York, N. Y.
Sperisen, Francis J., 166 Geary Street, San Francisco, California.
Stern Bros. Diamond Cutters Co., New York, N. Y.
Whitelaw Bros., 48 West 48th Street, New York, N. Y.

GRAPHITE - Per lb., f.o.b. New York, Ceylon Lump, 10¢ @ 12¢; carbon lump, 9¢ @ 10¢; chip, 7¢ @ 8¢; dust 4¢ @ 5¢; Madagascar flake 9¢ @ 10¢. Prices nominal.

No.1 flake, 9¢ @ 16¢; No.2, 7¢ upward; fine ground, 55 to 70 percent carbon, 3¢ upward; amorphous, 3¢ upward.

Flake graphite, 94 percent carbon, f.o.b. Georgia, 7¢ per lb.

Crude amorphous graphite, f.o.b. New York, $14. to $25 per ton, according to grade.

(Quotations February 1942).

POSSIBLE BUYERS OF GRAPHITE

Acheson Graphite Corp., 30 East 42nd Street, New York, N. Y.
Alatary, A.D., 10 Bridge Street, New York, N. Y.
Alatary Pitts Company, The, 85 Chestnut Hill Road, Newton, Mass.
Ashbury Graphite Mills, The, Ashbury, N. J.
Dixon Crucible Co. Joseph, Jersey City, N. J.
Great Lakes Carbon Corp., 22 East 40th Street, New York, N. Y.
Ilsley, Doubleday & Co., 56-14 Nurge Avenue, Maspeth, L.I., N. Y.
International Selling Corp., 67 Broad Street, New York, N. Y.
Los Angeles Chemical Co., 1960 Santa Fe Avenue, Los Angeles, Calif.
Paterson, Boardman & Knapp, 10 Bridge Street, New York, N. Y.
Pettinos, Charles, 1 East 42nd Street, New York, N. Y.
Shields Co., Thomas J., 11 Water Street, New York, N. Y.
Starkey & Co. J. F., 67 Prospect Avenue, White Plains, N.Y.
Superior Flake Graphite Co., 33 South Clark Street, Chicago, Ill.
Wallace Co. M.E., 112 Market Street, Sunbury, Pa.

REFERENCES:

Kraus, Edward Henry, and Slawson, Chester Baker,
Gems and Gem Materials. Third Edition
McGraw-Hill Book Company, 1939.
Pabst, Adolf. Minerals of California, California State Division of Mines Bulletin 113, 1938.
Ball, Sydney H., Precious Stones. Industrial Minerals and Rocks. Seely W. Mudd Series, A. I, M. E. 1937.
Miller, Benjemin L. Graphite. Industrial Minerals and Rocks. Seely W. Mudd Series A. I. M. E.. 1937.

Minerals Yearbook, Review of 1940, U. S. Bureau of Mines.

NOTES

Specimens of diamonds and graphite may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

FEBRUARY - 1942

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

DIATOMITE

By
George L. Gary, Mineral Technologist

PROPERTIES - Diatomite is a hydrous form of silica ($SiO_2.nH_2O$) commonly known as diatomaceous earth. It contains 2 to 10 percent combined water and varying amounts of inorganic impurities such as sand, crystalline silica, clay, volcanic ash, etc. Diatomite is white, cream, gray, tan, brown, or greenish to nearly black, depending upon the amount and nature of the impurities. Pure varieties are easily friable and apparently soft, due to porosity. Hardness 1 to 1.5. The actual hardness of the microscopic particles is 4 to 6. Specific gravity 1.9 to 2.35. Streak is white. Luster dull to earthy. Fracture parallel with bedding planes, conchoidal, or irregular.

OCCURRENCE - Diatomite is of organic origin and consists of the fossil remains of microscopic aquatic plants known as diatoms. Each organism is incased in a tiny siliceous shell, and when the plant dies it sinks to the bottom of the water where the organic material is decomposed. The residue of siliceous shells forms the deposit of diatomite. Diatoms were extremely abundant during the Miocene period and the best deposits are today found in Miocene sediments. Diatomite may occur in deposits laid down in fresh, brackish, or marine water.

The principal California deposits of diatomite are near Lompoc, Santa Barbara County, in the Monterey series of the upper Miocene. They occur at the surface as very pure, white beds as much as three square miles in area and several hundred feet thick.

In addition to the deposits near Lompoc, diatomite occurs in Fresno, Lake, Los Angeles, Monterey, San Luis Obispo, Shasta, Sonoma and Stanislaus Counties and on Santa Catalina Island.

PREPARATION - The first step in preparing diatomite is to remove the uncombined water by some drying process, either natural evaporation or in kilns. Pulverized diatomite is prepared by grinding sufficiently to free the individual shells. The material is screened and the coarser material is ready for packing. The finer diatomite is cleaned of impurities and classified by air after which it is sacked and ready for shipment.

USES - The principal uses for diatomite are in filtration, as a filler in cement, in insulating material, polishes and for refractories.

TESTS - Diatomite is infusible but becomes opaque. It yields its water of crystallation upon being heated in a closed tube. Microscopic examination is necessary for positive identification.

MARKETS - The following approximate price quotations for February, 1942, were furnished by Johns-Manville Sales Corporation. The price varies with the grade, quality, and quantity of material purchased.

Concrete admix diatomite ranges from $15. to $20. per ton in carload lots f.o.b. Lompoc, California. Bagged for filtration purposes, $45. per ton. For very fine material used in high grade polishes, the maximum price is about $110. per ton f.o.b. Lompoc. Depending upon the quantity purchased, the value of natural diatomite brick for insulating at relatively low temperatures (below 1500° C) ranges from $77. to $121. per ton f.o.b. Lompoc; that for insulating at higher temperatures (up to about 3000° C) ranges in value from $92. to $140. per ton f.o.b. Lompoc. Calcined brick for insulating at intermediate temperatures (between 1500° C and 3000° C) costs from $81. to $126. per ton f.o.b. Lompoc.

POSSIBLE BUYERS

California Spray Chemical Corp. Lucas & Ortho Way, Richmond, Calif.
Charles B. Crystal Co. Inc., 18 Hudson Street, New York, N. Y.
Daigger, A. & Co., 159 West Kinzie Street , Chicago, Ill.
Davidson, Harry H., 17 State Street, New York, N. Y.
Dicalite Company, The. 120 Wall Street, New York, N. Y.
Fortig, Arthur H., 373 Fulton Street, Brooklyn, N. Y.
Hammil & Gillispie, Inc., 225 Broadway, New York, N. Y.
Industrial Minerals and Chemicals Co., 6th & Gilman Streets, Berkeley, California.
Johns-Manville Corp., Lompoc, California.
Lite-Ore Minerals Corp., 136 Liberty Street, New York, N. Y.
Minerals Trading Corp. The, 17 Battery Place, New York, N. Y.
Owyhee Chemical Products Co., 435 North Michigan Avenue, Chicago, Ill.
Paraffine Companies, Inc. The. 475 Brannan Street, San Francisco, Cal.
Pomeroy & Fischer, Inc., 95 Madison Avenue, New York, N. Y.
Salamon, L. A. & Bro., 216 Pearl Street, New York, N. Y.
Schundler, F.E. & Co. Inc., 620 Railroad Street, Joliet, Ill.
Tams Silica Co., 228 North LaSalle Street, Chicago, Ill.
The Thomas Manufacturing Co., 117 Camden Street, Baltimore, Md.
Tropical Chemical Co. of California, 2444 East 8th St., Los Angeles, Cal.
Whittaker, Clark & Daniels, Inc., 260 West Broadway, New York, N. Y.
Wishnick-Tumpeer, Inc., 295 Madison Avenue, New York, N. Y.

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Arnold, Ralph, and Anderson, Robert. Diatomaceous Deposits of Northern California, Santa Barbara County, California. U.S. Geological Survey Bulletin 315, 1907
Cummins, Arthur B., and Mulryan, Henry. Diatomite. Industrial Materials and Rocks. Seeley W. Mudd Series A.I.M.E. 1937.
Hatmaker, Paul. Diatomite. U.S.Bureau of Mines Information Circular 6391, 1931.
Pabst, Adolf. Minerals of California. California State Division of Mines Bulletin 113, 1938.
Symons, Henry H. California Mineral Production for 1940. California State Division of Mines Bulletin 121.

NOTES

1. Specimens of diatomite may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, Cal.
2. Diatomite is also known as diatomaceous earth, kieselguhr or tripolite. However, the term diatomite is to be preferred.

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | February - 1942 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

FELDSPARS

By
George L. Gary, Mineral Technologist

The name feldspar is given to an important group of silicates of aluminum and sodium, calcium, potassium, or barium which are similar in hardness, cleavage, specific gravity and twinning.

PROPERTIES - Orthoclase is a potassium and aluminum silicate $KAlSi_3O_8$, but sodium may replace part of the potassium. It is of the monocline crystal system. The luster is vitreous. Color white, gray, pink or red. Cleavage in two directions at right angles. Hardness 6. Specific gravity 2.6.

Sanadine is a glassy, often transparent variety of orthoclase in which as much as 50 percent of the potassium is replaced by sodium. When orthoclase crystallizes at high temperatures (presumably 900°C) sanadine is formed.

Adularia is a colorless, or transparent variety of orthoclase which usually occurs in pseudo-orthorhombic crystals that serve to distinguish it. The other physical properties are the same for orthoclase.

MICROCLINE has the same chemical composition as orthoclase, as well as the same cleavage, hardness, specific gravity, etc. It is distinguished from orthoclase by physical properties. Specimens frequently are marked with irregular and discontinuous bands of albite (a plagioclase feldspar) which is intergrown into the microcline. A green feldspar is usually microcline. However, optical tests are often necessary to distinguish microcline from orthoclase.

The plagioclase feldspars are all triclinic and range from albite, a sodium and aluminum silicate ($NaAlSi_3O_8$) to anorthite a calcium and aluminum silicate ($CaAlSi_2O_8$). There is a perfect gradation in chemical composition between these two minerals and progressing from albite to anorthite the intermediate minerals are oligoclase, andesine, labradorite and bytownite. The plagioclase minerals as a group are generally colorless, white or gray, but they may be greenish or reddish. Labradorite nearly always shows a play of colors in blue or green and less often in red, yellow or gray which serves to distinguish it. Microscopic examination is required for positive identification of the individual plagioclase minerals.

FELDSPARS (continued)

Twinning striations parallel to the length of the crystal may usually be seen on the cleavage faces. Cleavage is good in two directions making an angle of about 90° with each other. Hardness 6. Specific gravity ranges from 2.61 to 2.76, increasing as the chemical composition progresses from albite to anorthite, i.e., with increase in the calcium content and decrease in sodium content.

OCCURRENCE - Feldspars are the most abundant and important of the rock forming silicates, and the classification of igneous rocks depends partly upon their prevailing feldspar.

Orthoclase and microcline are essential constituents of granites, syenites, quartz-porphyries, rhyolites, and trachytes.

Albite is a common constituent of granites, rhyolites, granodiorites, and diorites; also metamorphic gneisses and schists. It forms very important white veins in the crystalline schists of the Coast Ranges and the Sierra Nevada.

Oligoclase is a constituent of granodiorites, diorites, porphyries, and andesite. It is occasionally found in large white masses as veins in diorite and other basic rocks.

Andesine is a constituent of diorite, gabbro, andesite, and related rocks.

Labradorite is an essential constituent of most basic igneous rocks such as gabbros, diabases and basalts. It also occurs as veins.

Bytownite is uncommon, occurring rarely in certain basic and plutonic rocks.

Anorthite is a constituent of the very basic igneous rocks.

In 1939 the only production of feldspar in California came from Fresno and San Diego Counties.

PREPARATION - In the United States and Canada, feldspar is ground dry to the desired fineness. The composition or grade of the material is controlled by the addition of a "neutralizer" during the final grinding stage. (See Burgess, I.C. 6488 for details of this process). Iron fragments chipped or worn from the crushing and grinding equipment may be removed magnetically along with biotite, garnet, and other ferromagnesian minerals.

The requirements of the pottery trade demand that in general the percentage of free silica associated with the feldspar be less than 20 percent and in some cases less than 5 percent.

Some experimental work is being conducted toward separating quartz and feldspar by flotation.

USES - The principal use of feldspar is in the manufacture of pottery, enamel ware, porcelain insulators, brick, and tile. Other important uses are in the manufacture of glass, soaps, floor coverings, roofing materials, sandpaper, paint, wood-filler, and terra cotta. It is used as a binder in the manufacture of emery and corundum wheels. Very pure potash feldspar is used in artificial teeth.

FELDSPARS (continued)

Adularia is used as a gem stone and when opalescent, is called moonstone. Moonstone varieties of albite and oligoclase also occur. Amazon stone or amazonite, a bright green variety of microcline, resembles jade and is used as an ornamental stone. Sunstone or adventurine oglioclase is of a reddish color with bright yellow or red reflections of included crystals of iron oxide and is used for gem material. Colored labradorite is sometimes used for ornamental and gem material.

TESTS - Orthoclase and microcline are fusible at 5, and insoluble in acids. When mixed with powdered gypsum and heated on platinum wire they give the violet flame of potassium.

The plagioclase feldspars may usually be recognized by the parallel twinning striations. They are fusible to a colorless glass with increasing difficulty toward the anorthite end. Slightly attacked by hydrochloric acid, the solubility increasing toward the anorthite end. Calcium and aluminum can be determined by the standard wet tests.

MARKETS - Per ton, f.o.b. North Carolina, potash feldspar 200 mesh, white, $17.00, in bulk; soda feldspar, $19.00 f.o.b. Maine, potash feldspar, white, 200 mesh, $17.00, in bulk. Granular glass-spar, white, 20 mesh, f.o.b. North Carolina, $12.50 in bulk; semi-granular, $11.75; soda feldspar, 200 mesh, white, $19.00.

Virginia: No.1, 230 mesh, $18.00; 200 mesh, $17.00; No.17 glass-makers', $11.75; No.18, $12.50. Enamelers', $14.00 @ $16.00. Quotations on Spruce Pine, N.C. or Keene, N.H., basis. (Quotations December 1941).

POSSIBLE BUYERS

Clinchfield Sand and Feldspar Corporation, Hearst Tower Building Baltimore, Md.
Consolidated Feldspar Corporation, Trenton, New Jersey.
DuPont de Nemours, E.I. & Co. Inc., (The R. & H. Chemicals Dept.) Wilmington, Del.
Industrial Minerals & Chemical Co., 6th & Gilman Sts. Berkeley, Calif.
Schundler, F.E. & Co., Inc., 620 Railroad St. Joliet, Ill.
Whittaker, Clark & Daniels, Inc., 260 West Broadway, New York, N.Y.

REFERENCES

Bowles, O., and Lee, C.V. Feldspar. U.S. Bureau of Mines Information Circular 6381, 1930.
Burgess, B.C. Feldspar. Industrial Minerals and Rocks. Seeley W. Mudd Series. A.I.M.E. 1937.
Burgess, B.C. Methods of Milling Feldspar at the Minpro Plant, Tennessee Minerals Products Corporation, Spruce Pine, N.C. U.S. Bureau of Mines Information Circular 6488, 1931.
Pabst, Adolph. Minerals of California. California State Division of Mines, Bulletin 113, 1938.

NOTES - 1. Specimens of the feldspar group may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Celsian, a barium and aluminum silicate, $BaAl_2Si_2O_8$, is a monocline feldspar not so common as the other feldspars, having been reported from Mariposa County in California.

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | SEPTEMBER - 1941 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

FLUORSPAR

By
George L. Gary, Mineral Technologist

PROPERTIES - Fluorite, or fluorspar, a calcium fluoride, CaF_2 occurs usually in cubes; also massive, granular or compact. Cleavage perfect octahedral. Brittle. Luster vitreous. Streak white. The color varies widely; most commonly green, purple, blue, white, yellow, colorless. The hardness is 4 and the specific gravity 3.01-3.25. The phenomenon of fluorescence is shown by some varieties of fluorite and hence receives its name.

OCCURRENCE - Fluorite is a common and widely distributed mineral. It is usually found either in veins in which it is the chief mineral or as a gangue mineral with metallic ores, especially those of lead and tin. It is common in dolomites and limestone and has been observed also as a minor accessory mineral in various igneous rocks and pegmatites. It is associated with many different minerals, as calcite, dolomite, gypsum, celestite, barite, quartz, galena, sphalerite, cassiterite, topaz, tourmaline and apatite. In California deposits have been reported from Los Angeles, Mono, Riverside and San Bernardino counties.

PREPARATION - Some of the methods used in the separation of impurities from fluorspar are: selection in the mine, crushing, washing with jets of water or in log washers, hand picking on belts, screening, gravity concentration by jigs and tables, and flotation. The processes may be very simple, such as crushing, passing through single or double log washers, and screening the fluorspar from residual gravel deposits in order to prepare it for flux in open-hearth steelmaking; or they may be very complicated, as in preparation of vein fluorspar for the ceramic trade or for acidmaking, where it has to be freed of practically all impurities and reduced to great fineness.

USES - The steel industry is the chief consumer of fluorspar in the United States, followed in order by the hydrofluoric acid, glass, and enamel industries. Comparatively small quantities of fluorspar are used in a number of miscellaneous operations, such as production of the finer grades of iron castings, nickel and Monel metal, cement, ferro-alloys, carbon electrodes, and calcium carbide

FLUORSPAR (Continued)

and cyanamid; reducing aluminum; refining lead and silver; extracting various rare metals from their ores; smelting refractory ores of gold, silver, and copper; as a paint pigment; and as a binder in abrasives.

TESTS - Fluorite is fusible at 3, and residue gives alkaline reaction to moistened turmeric paper. Gives a reddish flame (calcium). When it is mixed with potassium disulfate and heated in a bulb tube, hydrofluoric acid is evolved which etches the glass, and a white deposit of silica forms upon the walls of the tube.

MARKETS - Fluorspar, per net ton, 85 percent CaF_2, and not over 5 percent SiO_2, Kentucky and Illinois, in bulk f.o.b. mines, washed gravel $21 for all rail movement; $21 for barge movement. No. 2 lump, $21 f.o.b. mines. Ground fluorspar, f.o.b. Illinois mines, 95 to 98 percent CaF_2 and not over 2½ percent SiO_2, $31 in bulk; $32.60 in bags and $36.60 in barrels. Acid fluorspar, 98 and 1 percent, $27, f.o.b. mines. F.o.b. Colorado mines, 82-6, $13.50. Foreign fluorspar, gravel, 85-5, $25.50 per net ton, duty paid, Baltimore or Philadelphia. Nominal. (Quotations August 14, 1941.)

POSSIBLE BUYERS

E. I. du Pont de Nemours & Co., Inc. (The R. & H. Chemicals Department), Wilmington, Del.
Foote Mineral Company, 1609 Summer St., Philadelphia, Pa.
Charles W. Garland Co., 412 W. Sixth St., Los Angeles, Calif.
General Chemical Co., 40 Rector St., New York, N. Y.
Industrial Minerals & Chemical Co., 6th and Gilman Sts., Berkeley, Calif.
International Selling Corp., 67 Broad St., New York, N. Y.
The McGean Chemical Co., 1106 Republic Bldg., Cleveland, Ohio.
Mercantile Import & Export Corp., 21 East 40th St., New York, N. Y.
Pennsylvania Salt Manufacturing Co., 1000 Widener Bldg., Philadelphia, Pa.
Strategic Materials Corp., 210 West 7th St., Los Angeles, Calif.
Whittaker, Clark & Daniels, Inc., 260 West Broadway, New York, N. Y.

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Ernest F. Burchard. Fluorspar and Cryolite. Industrial Minerals and Rocks. The American Institute of Mining and Metallurgical Engineers. New York, 1937, pp. 283-302.
H. W. Davis and M. E. Trought. Fluorspar and Cryolite. Minerals Yearbook (1940) pp. 1333-1351.
Adolf Pabst. Minerals of California. Calif. State Div. of Mines. Bull. No. 113. (1938)

NOTES

1. Specimens of fluorspar may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Cryolite, a fluoride of sodium and aluminum, Na_3AlF_6 is the only other commercial fluoride. The only important deposit of this mineral is at Ivigtut, on the west coast of Greenland.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | NOVEMBER 1941 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

GOLD

By
George L. Gary, Mineral Technologist

The gold mining industry in California is second only to the petroleum industry in importance.

PROPERTIES - Native gold (Au) is usually found finely disseminated through its containing rock and occasionally in large nuggets. Crystals are rare. The color is deep to pale yellow. The pale yellow variety containing over 20 percent silver is known as electrum. The luster is metallic, streak (on touchstone) like color, hardness 2½ to 3, specific gravity 15 to 19 (according to purity).

Calaverite (gold telluride, Au,Te_2. 44 percent gold) usually occurs in small striated, elongated crystals along seams. The color is pale brass yellow somewhat resembling pyrite. The luste is metallic, hardness 2½, specific gravity 9.

Sylvanite (gold silver telluride, $(Au,Ag)Te_2$. 24.2 percent gold, 13.3 percent silver) is usually found in branching crystal aggregates. The cleavage is perfect in one direction, color silver white to steel gray with a yellow tinge, luster metallic, hardness 2, specific gravity 8.0 to 8.3.

OCCURRENCE - Gold has been found in every county in California and is now produced in 50 of the 58 counties. Practically all of the gold exists as the native metal, either as free gold in quartz veins and gravels or mechanically mixed with the sulfides of iron, copper, lead or zinc. Gold tellurides occur in California but they are not abundant.

Gold in quartz is the usual association, and the mineral is often in the quartz in such a finely divided state as to be invisible even in high grade ore.

Gold in pyrite is abundant and is the source of much of the gold produced in the State.

The major regions in California where gold occurs in lodes are the Mother Lode Belt, the Nevada City, and Grass Valley districts.

The Mother Lode Belt extends from the northern boundary of El Dorado County on the Middle Fork of the American River near Georgetown, south to Mormon Bar, 2 miles south of Mariposa, in Mariposa County. Its direction roughly parallels the main axis of the Sierra Nevada. The vein system is associated with rocks of a slaty or schistose character which have been subjected to great compressive stresses or hydrothermal alteration along the overthrust

fault zone. The fault zone has given access to mineralizing solutions from deep-seated sources at the time of the batholithic invasion of the overlying rocks when the Sierra Nevada were formed.

The gold deposits of the Mother Lode Belt form two main groups - quartz veins and ore bodies of mineralized country rock.

There is no geologic relation between the Mother Lode Belt and the Grass Valley-Nevada City veins. These gold bearing veins occur on north-south and east-west fissure systems and were produced by hot ascending aqueous solutions.

Other lode gold sections include the Klamath Mountains, and the desert area in southern California.

The principal gold placer area of California lies in the Sierra Nevada between Lassen County on the north and Mariposa County on the south; also the Klamath Mountains in Siskiyou and Trinity counties.

This area includes practically all of the eastern tributaries to the Sacramento and San Joaquin rivers; among them the well known American, Bear, and Yuba rivers; also the rivers of the Klamath Mountains.

Of lesser importance are the dry placers of Southern California, the upper section of the Kern River, and various outlying districts in the Sierra Nevada and Coast Ranges.

PREPARATION - Gold may be recovered by (1) amalgamation, cyanidation, and the flotation of gold ores, (2) by the washing of placer gravels, and (3) by the refining of base bullion.

Amalgamation of free gold with mercury is the principal method of recovering coarse gold before either cyanidation or flotation. One method of amalgamation consists of crushing and grinding the ore sufficiently to free the gold from the gangue and passing the resulting pulp over silvered copper plates coated with quicksilver which amalgamates with the gold. Periodically the gold amalgam is scraped from the plates and retorted to drive off the mercury leaving nearly pure gold. The mercury is collected and used again.

Other processes differ only in the manner of amalgamation which may be done in rotary cylinders or at the time of grinding.

If there is sufficient gold in the tailings to warrant recovery, it may be obtained by cyanidation or flotation or a combination of both.

The cyanidation process for recovering gold is based on the fact that finely divided gold is soluble in potassium cyanide (KCN). The pulp to be leached is first treated with lime to neutralize any acids which would decompose the cyanide solution, then fed into tanks where the cyanide solution is allowed to percolate through it, dissolving the gold particles. When leaching is complete, the solution containing the dissolved gold is drawn off and the pulp is washed to extract the remainder of the solvent. The cyanide solution is then piped to the zinc box where zinc is added to the solution, precipitating the gold along with lead and any impurities present such as arsenic, antimony, copper, etc. The gold is finally recovered by smelting and refining.

In recent years, the development of the flotation process has made possible the recovery of finely divided gold. This process depends on the fact that certain minerals will adhere to an air-water interface, which is produced when bubbles are formed in a liquid,

GOLD (continued)

and which permits the minerals to be lifted to the surface and removed in a froth. The other minerals do not adhere to the air-water interface and are left behind.

In actual practice, the froth is produced by mechanical agitation of pine oil and cresylic acid in water or cyanide in a flotation cell. A "collector" is added to the pulp which superficially alters the surface of the mineral particles so that they will adhere to the air-water interface. "Depressors" may be added which prevent unwanted minerals from floating. The net result of the process is to produce a froth containing the valuable mineral and a barren tail of gangue minerals.

Gold is generally recovered from pyritic ores by amalgamation followed by flotation of the tailings.

If part of the gold is coarse, this portion should be removed from the pulp by amalgamation before flotation.

Telluride gold ores can be floated in a cyanide solution.

The carbonaceous slime tailings of the Mother Lode District have been treated successfully by flotation.

Gold is recovered from placer gravels by various gravity concentration methods such as dredging, hydraulicking, drift mining of the buried gravels, various forms of ground sluicing, dry washing, and panning.

Precious metals are recovered from copper and lead bullion (base bullion) by electrolytic refining. Gold and silver are also removed from lead bullion by the Parkes Process which depends on the strong affinity of metallic zinc for gold and silver. Zinc is stirred into the liquid lead bullion where it melts and reacts with gold and silver to form a material of higher melting point but lower specific gravity than the lead. Consequently the zinc containing the precious metals rises to the top of the kettle and is skimmed off. The zinc crust is sent to a silver refinery for the final removal of gold and silver.

USES - Gold was formerly used in coins but is now used principally for jewelry. Other uses are in dental work and as gold leaf for signs.

TESTS - Gold is easily recognized from other metallic minerals as well as from yellow mica by its malleability and high specific gravity. It is distinguished from pyrite and chalcopyrite by the fact that both sulfides are brittle and soluble in nitric acid, whereas gold is insoluble in any single acid. Gold fuses at 1063°C.

When free gold is present in relatively small quantities, it may be detected by grinding a representative sample of the material, then washing and panning it to remove the gangue. This test should be made on a sample weighing at least one pound. The ore is first pulverized, then sifted through a fine screen which will catch any gold flakes that were flattened during the grinding. The fine ore which passed the screen together with the metal left on the screen is put in a pan containing about 1/4 of a teaspoonful of mercury. The pan is immersed in water and agitated for a short time to allow the gold to settle to the bottom. When the operator is reasonably certain that the gold has had time to collect in the bottom, the pan is tilted while continuing the agitation, so as to wash away the

GOLD (continued)

lighter gangue or worthless material. This is continued until there remains only a concentrate of some of the heavier gangue minerals and gold amalgamated with the mercury. To remove the last bit of gangue the concentrate is transferred to a mortar and ground in a stream of water which will carry away the fine particles of lower specific gravity than the gold. The remaining gold-mercury amalgam is then dried with blotting paper and placed on charcoal in preparation for volatalizing the mercury with a blowpipe. By prolonged heating practically all of the mercury may be driven off leaving a bead of gold which usually contains some silver, and possibly a little platinum.

When testing the gold tellurides, the ground ore (about 1 pound) first must be roasted before applying the above method of detection. Roasting may be done by putting the ore in an iron pan or a piece of sheet iron with the edges turned up, and heating to a dull red for about an hour, stirring the ore occasionally with an iron wire.

By simply panning a finely ground ore, the gold may usually be detected as "color" in the pan.

MARKETS - Under the Gold Reserve Act of 1934 the value of gold was fixed by Presidential Proclamation on January 31, 1934, at $35. per fine troy ounce. From January 18, 1837, through 1932 the price was $20.67 per ounce.

POSSIBLE BUYERS - In addition to the United States Mint at San Francisco, there are several hundred licensed gold buyers in the State and it is impossible to list them all in a condensed report. Practically every city and town in the gold producing districts has one or more gold buyers licensed by the State of California.

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Newton, Joseph. An Introduction of Metallurgy. John Wiley & Sons, Inc., New York. Chapman & Hall, Limited, London. 1938.
Pabst, Adolf. Minerals of California. Bulletin 113. California State Division of Mines. 1938.

NOTES

1. Specimens of gold and gold bearing minerals may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Other gold bearing minerals are krennerite $(Au,Ag)Te_2$. petzite $(Ag,Au)_2Te$. and nagyagite a sulfo-telluride of lead and gold.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

APRIL - 1942

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

GYPSUM

By
George L. Gary, Mineral Technologist

PROPERTIES - Gypsum ($CaSO_4.2H_2O$) hydrous calcium sulfate (79.1% $CaSO_4$, 20.9% H_2O), occurs often in tabular, prismatic or acicular crystals, in cleavage and crystalline masses, and in fibrous or granular masses. The cleavage is perfect in one direction. Luster vitreous, silky or pearly. Colorless, white, gray, light brown, reddish brown or black if impure. Hardness 2 to 2½. Specific gravity 2.32.

OCCURRENCE - Commercial gypsum usually occurs as bedded sedimentary deposits which have been precipitated from saline waters. The normal sequence of precipitation of salts from evaporating sea water is (1) calcium carbonate, (calcite or limestone), (2) calcium sulfate (gypsum), (3) sodium chloride (rock salt) and finally (4) magnesium and potassium compounds. From this sequence one might expect to find gypsum deposits overlying limestone and underlying rock salt. However, this is not always the case because re-solution and movement of the compounds before consolidation may alter their relative position Under certain conditions anhydrite is precipitated instead of gypsum. (see Note 2 at end of paper).

Outcrops of gypsum are very often underlain by anhydrite and this may be due to the fact that anhydrite alters to gypsum after prolonged exposure.

Gypsum is common in California and has been shipped from Fresno, Imperial, Kern, Monterey, and Riverside counties. The largest recent shipments have come from Kern County.

The most important gypsum deposits in the United States are located in the Middle West in Iowa, Kansas, Oklahoma, Texas, and in the Rocky Mountains.

PREPARATION - Calcined gypsum is the only gypsum product that requires any treatment other than crushing, grinding, classifying and drying.

Gypsum is usually calcined in kettles, although rotary kilns may be used. The kettles are steel shells about 10 feet in diameter, set in brick and surrounded by steel jackets. The capacity ranges from 8 to 15 tons and the process takes from one to two hours. The maximum temperature reached is generally between 330°F and 340°F.

USES - Most of the gypsum produced is calcined and used in various types of plaster, including wall plaster, plaster of Paris, molding, casting, and finishing plaster, etc. Keene's cement is made from

completely dehydrated gypsum plus an accelerator. Lath and wallboard are also made from gypsum.

Land plaster is uncalcined gypsum, ground to the desired fineness, and applied to the soil to neutralize alkaline conditions, and where peanuts are grown to conserve moisture and absorb nitrogen from manures. Ground plaster is also used as a filter in some paints and cloth.

Untreated gypsum acts as a retarder in cement and is crushed to minus one-half inch then ground with the cement clinker.

It is used as a flux in the smelting of nickel ores.

TESTS - Gypsum fuses at about 3, coloring the flame reddish yellow (calcium) especially with hydrochloric acid. It is readily soluble in water. Barium chloride precipitates barium sulfate from solution; if the solution is made alkaline with ammonium hydroxide, calcium may be precipitated by adding ammonium oxalate. The taste of gypsum is salty and bitter.

Gypsum is distinguished by its softness, although it is harder than talc.

MARKETS - The price of crude gypsum ranged from $1.25 to $3.00 per ton in 1941.

POSSIBLE BUYERS:

California Chemical Co., Div. of Westvaco Chlorine Products Corp., Newark, California.
Consolidated Minerals Co., P. O. Box 92, Long Island City, N. Y.
Geo. S. Mepham Corp., 20th & Lynch Avenues, East St. Louis, Ill.
National Gypsum Co., 608 16th Street, Oakland, California.
Pacific Portland Cement Co., 417 Montgomery St., San Francisco, Calif.
U. S. Gypsum Co., 300 West Adams Street, Chicago, Ill.
Whittaker, Clark & Daniels Co., 260 West Broadway, New York, N. Y.

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Bradley, W. G.. Methods and Costs of Mining and Crushing Gypsum at the mine of the Blue Diamond Corporation, Arden, Nevada. U. S. Bureau of Mines Information Circular 6615, 1932.

Newland, D. H. and H. J. Brown. Gypsum. Industrial Minerals and Rocks. Seeley W. Mudd Series, A.I.M.E. 1937.

Pabst, Adolf. Minerals of California. California State Division of Mines Bulletin 113, 1938.

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--- Minerals Yearbook Review of 1940. U.S. Bureau of Mines 1941.

NOTES:

1. Specimens of gypsum, and anhydrite may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California

GYPSUM (continued)

NOTES (cont'd)

2. Anhydrite ($CaSO_4$) anhydrous calcium sulfate, occurs in bedded deposits or as veins and is used for fertilizer. It is a rock as well as a mineral.

3. Secondary deposits of impure, loosely compacted gypsum are known as"gypsite".

4. There are several varieties of gypsum. Selenite is the transparent cleavable variety; satin spar is fibrous; and alabaster is the massive, translucent, white or pink variety.

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley State Mineralogist	JULY - 1941	Ferry Building San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

IODINE

By
George L. Gary, Mineral Technologist

PROPERTIES - Iodine is a grayish-black, crystalline solid, with metallic luster, brownish-red in thin layers, which volatilizes easily and gives off a violet vapor. Even at ordinary temperatures it volatilizes spontaneously in the air, diffusing an odor similar to that of chlorine. The vapor is one of the heaviest known gases, having a specific gravity of 8.8. The characteristic color of this vapor gave the element its name, which is derived from the Greek word for "violet".

OCCURRENCE - Iodine in minute quantities is quite widely distributed. As a mineral it occurs in combination with silver, mercury, lead and zinc. Iodine is always present in sea water, but the percentage is so small that it is difficult even to detect its presence. Certain seaweeds are able to absorb iodine within their cell structure and by burning such weeds an ash comparatively rich in iodine may be obtained. Iodine occurs in the form of iodates in nitrate deposits and it also is found in coal and oil well waters in commercial amounts. Iodine was first produced in California during 1917 to 1921 as a by-product of potash which was reduced from kelp in an experimental station of the U. S. Dept. of Agriculture at Summerland, in Santa Barbara County. In 1929 the General Salt Company erected a plant which reduces iodine from the waste waters of certain deep oil wells in the Long Beach field of Los Angeles County. During 1933 two more plants started operations, making a total of three producing plants in the State.

PREPARATION - The methods of extracting iodine from nitrates and kelp may be found in Information Circular 6387 and the process in use by the General Salt Company was described in Chemical and Metallurgical Engineering in November 1934; both papers are listed in the attached bibliography. The latter process consists of liberating the iodine by acid, absorption in activated carbon and subsequent removal with alkali, after which the iodine is liberated and refined.

IODINE (Continued)

USES - Iodine is used largely in medicine in the form of its salts; by far the most important is potassium iodide; others include sodium iodide, arsenious iodide, mercuric iodide, iron iodide and strontium iodide. Potassium iodide is obtained in white, colorless crystals and is used in medicine and in sensitizing solutions for photographic films; it is also an important reagent in chemical laboratories. The lack of iodine in the human system is said to cause goiter, and in some localities the municipal authorities cause iodine to be dissolved in the drinking water supply from public works. Iodine is also added to table salt as a corrective or preventive of thyroid diseases. In alcoholic solutions iodine is a well-known antiseptic, and the element is often sprinkled about hospitals as a disinfectant. In analytical chemistry iodine is invaluable; and as a fertilizer, the addition of an iodide to certain soils is said to result in substantially greater yields of crops. Iodine is also said to be used as an ingredient in certain dyes and paints.

TESTS - Iodine is recognized by the yellow to black color when mixed with water; the violet color when dissolved in carbon disulphide; the reddish color when dissolved in chloroform or ether; the blue color when added to a cold solution of starch; the violet color of its vapors. The reactions of iodine are similar to those of chlorine and bromine. Silver nitrate precipitates silver iodide, AgI, which differs from silver chloride and silver bromide in being almost insoluble in ammonia, with potassium in a bulb tube, either with or without pyrolusite, iodine is liberated, and may be recognized by its violet vapors, or, if the reaction is strong, by its crystallization in the tube.

MARKETS - Iodine, crude, jars, 25 lbs., lb. 1.67; kgs., 150 lbs., less 5% ex whse, Staten Island, lb. 1.35; resubl. bots., 5 lbs. lb. 2.10; jars, 50 lbs; lb. 2.00. (Quotations June 16, 1941)

POSSIBLE BUYERS

J. T. Baker Chemical Co., Phillipsburg, N. J.
Chilean Nitrate Sales Corp., 120 Broadway, New York, N. Y.
The Dow Chemical Co., Midland, Mich.
General Chemical Co., 40 Rector St., New York, N. Y.
Mallinckrodt Chemical Works, St. Louis, Mo.
Mefford Chemical Co., 1026 Santa Fe Ave., Los Angeles, Calif.
Merck & Co., Inc., Rahway, N. J.
The New York Quinine & Chemical Works, Inc., 99 North 11th St., Brooklyn, N. Y.

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Paul M. Tyler and Amy B. Clinton. Bromine and Iodine. U. S. Bur. of Mines Inf. Circ. 6387 (1930).
Paul M. Tyler and A. T. Coons. Iodine. Minerals Yearbook 1940, p. 1446.

NOTES

Specimens of iodides may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, Calif.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

JULY - 1942

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)
IRON
By
George L. Gary, Mineral Technologist

PROPERTIES - The principal ore minerals of iron are hematite (specular iron ore, red hematite, fossil ore) Fe_2O_3; limonite (brown hematite, bog ore, brown ore) $H_2Fe_2O_4(H_2O)_x$; magnetite (lodestone) Fe_3O_4; and siderite (spathic ore, black band, clay-ironstone, kidney ore) $FeCO_3$.

Hematite contains 70.0 percent Fe. It occurs as micaceous fibrous oolitic, massive compact, and earthy forms, and is found as small crystals in cavities. Crystals are hexagonal, usually tabular or low rhombohedral in habit. The luster is metallic to dull; color, iron black to dark red; streak, brownish red; hardness 6; specific gravity 5.2.

Limonite contains 50 to 60 percent Fe, 13 to 18 percent water and is often impure due to the presence of manganese oxides, phosphates, clay, sand, and organic matter. It occurs in stalactitic, botryoidal, or mammillary crusts, and in compact pistolitic, nodular, porous and earthy masses. It is often pseudomorphous after other iron minerals, especially pyrite. The luster is submetallic to dull and earthy. It may also be silky. The color is yellow, brown or black; yellowish brown; hardness 5½; specific gravity 3.8.

Magnetite contains 31.0 percent FeO, 72.4 percent Fe and sometimes contains up to 6 percent TiO_2. It occurs in loose and attached crystals, in compact and granular masses, and as sand. It is strongly attracted by the magnet and sometimes acts as a magnet itself (lodestone). The luster is metallic; color, black; streak, black; hardness 6; specific gravity 5.1.

Siderite in the pure state contains 48.27 percent Fe. It occurs as small crystals in cavities, in cleavable masses, in botryoidal crusts, in cellular forms ("boxwork" siderite), in concretions, and in oolitic masses. The common crystal form is the unit rhombohedron which may be curved like those of dolomite. The luster is high virteous or sub-adamantine; color, various tints and shades of brown and gray; cleavage, rhombohedral; hardness 3½ to 4; specific gravity 3.8.

IRON (Continued)

OCCURRENCE - Hematite is the most abundant ore of iron. It is found in contact metamorphic deposits, and in basic igneous rocks as a late magmatic mineral. It replaces siliceous rocks on a large scale, and is found in connection with regionally metamorphosed rocks where it may have originated by the alteration of limonite, siderite, or magnetite. Like limonite, it may be formed in irregular masses and beds as the result of the weathering of iron-bearing rocks. The oolitic ores are of sedimentary origin. It may occur as a sublimation product in connection with volcanic activity.

The chief iron-ore districts of the United States are grouped around the southern and northwestern shores of Lake Superior in Michigan, Wisconsin, and Minnesota. The ore mined here amounts to from 80 percent to 90% of the total domestic output and is mainly hematite.

Limonite ranks next to hematite in importance as an ore of iron in the United States. It occurs as a secondary mineral in veins and ore deposits formed by the oxidation of pyrite, and as a metasomatic replacement of limestone.

The largest magnetite deposits in the world are in northern Sweden at Kiruna and Gillivare. In the U. S. the principal deposits are in the Adirondack region in New York, New Jersey, Pennsylvania, and Utah. It occurs as a contact mineral between igneous rocks and limestones, and in detrital deposits as the main constituent of the so-called black sands which are prominent on the Pacific Coast.

Siderite, (iron carbonate), one of the minor ores of iron, is found as a secondary mineral in cavities of basalt, and as a metasomatic replacement of limestone.

Recent shipments of iron ore in California have been made from Inyo and Santa Cruz Counties. Other occurrences of hematite, limonite and magnetite in California are in Alameda, Alpine, Amador, Butte, Calaveras, Colusa, Del Norte, El Dorado, Fresno, Humboldt, Imperial, Kern, Lake, Lassen, Los Angeles, Mariposa, Mendocino, Mono, Napa, Nevada, Orange, Placer, Plumas, Riverside, San Benito, San Bernardino, San Diego, San Luis Obispo, Shasta, Sierra, Sonoma, Tehama, Trinity, Tulare, Tuolumne, and Yuba counties.

PREPARATION - Iron ore minerals must contain at least 30 to 40 percent of iron. Pig-iron or cast-iron is produced by smelting the ores in a blast furnace to yield an iron alloy containing about 4 percent carbon and lesser amounts of silicon, manganese, sulfur, and phosphorus. Various commercial grades of "pig" are produced, each intended for a specific purpose. The important types of pig-iron are (1) foundry or remelting iron for iron castings and malleable castings; (2) puddling, forge, or mill iron for making wrought iron; (3) steel-making irons (Bessemer pig, low phosphorus pig, basic iron); (4) ferrovanadium, ferrotungsten, ferrochromium, ferrosilicon, etc., for making ferroalloys.

List (Continued)

Steel is produced by refining pig-iron, by remelting steel scrap, or by a combination of these methods. The refining may be done in one of the following ways:

1. Refining pig-iron and steel scrap by the basic open-hearth process to produce basic open-hearth steel.
2. Refining pig-iron by the acid Bessemer process to produce Bessemer steel.
3. Refining pig-iron and scrap in the acid open-hearth furnace to make acid open-hearth steel.
4. Duplexing - refining by the duplex process in which the product of the acid Bessemer is given additional refining in a basic open-hearth furnace.

Higher quality steels are made by one of the two processes:

1. Crucible process, in which high-grade wrought iron is melted down with carbon in small crucibles. At present the amount of crucible steel produced in the United States is almost negligible.
2. Refining pig or scrap in electric furnaces. This is the most important method of producing high-quality steel, and the larger part of the electric steel output is alloy steel.

Wrought iron is a slag-bearing malleable iron containing very little carbon. It is manufactured (1) by refining pig-iron in a puddling furnace, or (2) by shooting metal from the Bessemer converter through a bath of siliceous slag (Aston process).

Ingot iron is commercially pure iron, with total impurities less than 0.10 percent, which is made by a special basic open-hearth process.

USES - Iron in the form of commercially valuable ore is the most abundant of the metals found in the earth's crust. In total amount it is surpassed only by the metal aluminum. The widespread use of iron in the arts and industries is due primarily to two important facts, viz:

1. Iron forms a long series of useful alloys with carbon.
2. The widespread distribution of high-grade iron ores permits the metal to be produced cheaply and on an enormous scale.

In addition, iron has unique magnetic properties which make it invaluable for many purposes.

Chemically pure iron is difficult to prepare, and electrolytic iron (which is produced only on a small scale) is the only commercial metal which approaches the composition of pure iron. Practically all commercial iron exists in the form of iron-carbon alloys.

Alloys of iron:

White cast-iron or chilled cast-iron is obtained by cooling a cast-iron rapidly enough to prevent decomposition of any of the carbide. It is too brittle to be used alone and is generally used as a chilled surface on gray iron castings, or as a raw material for the manufacture of malleable cast-iron.

IRON (Continued)

Malleable cast-iron is prepared by annealing white cast-iron articles so that the carbon separates in the form of finely divided graphite or temper carbon. Malleable castings are used only for small articles such as pipe fittings and harness buckles. The term "malleable iron" means that the alloy is less brittle and more resistant to shock than gray cast-iron, and not that it is shaped by forging or rolling.

Steel is more widely used than all other metals and alloys combined. It is employed for building construction, bridges, machinery, tools, rails, etc.

Alloy steels: Nickel steel ordinarily contains from 1.5 to 4.0 percent Ni, and 0.25 to 0.4 percent C. It is used in motor shafts, axles, connecting rods, structural work, engine forgings, etc. Invar, which contains 36 percent Ni has the lowest coefficient of thermal expansion of any known metal or alloy and is used in making clock pendulums, surveyor's tapes, and similar articles. Platinite containing 42% Ni has the same coefficient of expansion as glass and is used in making electrical connections to be sealed to glass.

Chrome-nickel steel (stainless steel) usually contains from 0.45 to 0.95 percent Cr and 1.00 to 3.25 percent Ni and is used widely in crankshafts, axles, and other motor and machine parts.

Manganese steel commonly contains about 14 percent Mn and 1 percent C. When a piece of manganese-steel is subjected to blows, its surface work-hardens and offers greater resistance to abrasion. Manganese steel is used for such purposes as ball-mill liners, crusher jaws and mantles, power shovel buckets, railroad frogs and crossings, and burglar-proof safes.

Alloy cast-iron usually contains small amounts of nickel and chromium or nickel alone. These cast irons are stronger, denser, and have a finer grain than ordinary cast-iron, and they machine well.

TESTS - Hematite is distinguished from magnetite, ilmenite, and limonite by its brownish-red streak. Limonite is distinguished from hematite by its yellow-brown streak and from goethite by the absence of fibrous structure and by its optically isotropic character. Magnetite is distinguished from all other black minerals by its strong magnetism. Siderite is distinguished from brown calcite by its comparatively high specific gravity, and from sphalerite by its rhombohedral cleavage and high vitreous luster.

On charcoal in a reducing flame, especially with sodium carbonate, iron minerals become magnetic. (This test must be tried after the assay has become cold.) Cobalt and nickel compounds give a similar test. In the oxidizing flame, the borax bead is amber colored, and in the reducing flame, pale green. Ammonium hydroxide precipitates brownish-red $Fe(OH)_3$ from solutions containing ferric iron. A few drops of HNO_3 should be added to the solution to insure oxidation of the iron to the ferric condition. To detect the state

Page (continued)

of the iron, a borax bead made blue with CuO (or malachite) is changed to opaque red by a ferrous compound, and to green by a ferric compound. (Use a neutral flame). To detect the state of iron in insoluble minerals (especially silicates) fuse the powdered mineral with a large excess of borax in a test tube. Break the tube and dissolve the finely powdered contents in HCl. Divide the solution in two portions and test one with $K_4Fe(CN)_6$ (ferric compounds give a deep blue precipitate) and the other with $K_3Fe(CN)_6$ (ferrous compounds give a dark blue precipitate).

MARKETS - Per long ton Lake Superior ore quotations: Mesabi, non-bessemer, 51½ percent iron. $4.45. Old Range bessemer $4.60. Mesabi, bessemer 51½ percent iron. $4.60. Old Range bessemer $4.75. Eastern ores, cents per long ton unit, delivered at furnaces: Foundry and basic, 56 percent to 63 percent, 11¢ @ 12¢ (quotations June 1942).

POSSIBLE BUYERS

Alabama Mineral Ore Co., 5005 West 25th St., Cicero, Illinois.
Bowring & Company, 17 Battery Place, New York, N. Y.
Leonard J. Buck, Inc., 1 Newark Ave., Jersey City, N. J.
Paramount Safety Products Co., 368 Broadway, New York, N. Y.
Sicklick & Company, Ltd., 40 East 49th St., New York, N. Y.
Tehuantepec Export, Inc., 610 South Main St., Los Angeles, Calif.
Tutein Corporation, 230 Park Ave., New York, N. Y.
E. Arthur Tutein, Inc., 52 Vanderbilt Ave., New York, N. Y.

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NOTES

1. Specimens of iron ores may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, Calif.
2. In the Bessemer ore the iron content is at least 1000 times the phosphorus content.
3. Goethite, ($Fe_2O_3.H_2O$) is a minor ore of iron.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

AUGUST - 1941

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

LEAD

By
George L. Gary, Mineral Technologist

PROPERTIES - Galena, a lead sulfide, PbS, is practically the only source of lead. It occurs in many forms, mainly massive cleavable, coarse or fine granular, to impalpable; occasionally fibrous or plumose. The cleavage is cubic, highly perfect. Luster metallic. The streak and color is lead-gray. The hardness is 2½ and the specific gracity 7.4-7.6.

OCCURRENCE - Galena is a very common metallic sulfide, found in veins associated with sphalerite, marcasite, chalcopyrite, cerussite, anglesite, dolomite, calcite, quartz, barite, and fluorite. The veins are commonly in igneous rocks or show a close connection with such rocks. In such deposits galena is frequently found with silver minerals and often contains that metal itself and so becomes an important silver ore. A large part of the supply of lead comes as a secondary product from ores mined chiefly for their silver. A second type of galena deposit is associated with limestone, either as veins, open-space fillings, or replacement deposits. The replacement deposits in limestone are commonly accompanied by a dolomitization of the rock and may have no apparent association with igneous rocks. Galena is also found in contact metamorphic deposits.

PREPARATION - Lead is derived from its ores by methods of roasting and reduction in both blast and reverberatory furnaces. Galena containing gold, silver and other valuable metals, also the oxidized ores, (oxides and carborates) are treated in blast furnace. The charge consists of coke, ore and fluxes. The lead is separated from the ore and collected as 'base bullion.' The sulfur forms with the copper and iron a 'matte,' while the remaining bases unite with the silica to form 'slag.' If there are not bases enough in the original ore to form a suitable slag, fluxes must be added. The 'base bullion' is refined for the production of pure lead, and the recovery of the gold, silver and other precious metals. The lead copper 'matte' is resmelted and refined. High-grade non-siliceous

LEAD (Continued)

ores containing little silver, are best treated by roasting and reduction in the reverberatory furnace. This process may be divided into two stages, namely oxidation and reduction. The ore is ground fine, spread out evenly over the hearth, and heated for several hours, at comparatively low temperature (500° to 600° Centigrade). The charge is frequently raked over to expose new surface to the action of the heat and air. Only part of the galena is changed to lead sulfate, the remainder being unaltered. The temperature is then raised to about 700° Centigrade, when the oxide and sulfate formed in the first stage, re-act with the unchanged galena, producing metallic lead, which flows down the inclined hearth and collects in a basin, while the sulfur dioxide gas passes off through the flue. Slaked lime is often added to stiffen the charge and to make it spongy. The process of oxidation and reduction is repeated several times, before the greater part of the lead is obtained from the charge, each successive operation being shorter and the temperature higher. Towards the end, coal or charcoal is added for further reduction. The slag residue may still contain considerable lead, and this is treated in the blast furnace. The refining of the bullion is accomplished by electrolysis.

USES - Metallic lead is used to make storage batteries, cable coverings, pipes, foil, weights, bullets and shot. It is a constituent of various alloys such as solder (lead and tin), type metal (lead and antimony), low fusing alloys (lead, bismuth, and tin). A large amount of lead is used in the form of the basic carbonate, $(PbOH)_2Pb(CO_3)_2$, which is known as white lead and is very valuable as a paint pigment. The oxides of lead, litharge, PbO, and minium, Pb_3O_4, are used in making fine grades of glass, in glazing earthenware, and as pigment. Lead chromates are used as yellow and red paints. Lead acetate, known as sugar of lead, has important uses in various industries.

TESTS - With soda on charcoal a malleable globule of metallic lead is obtained from lead compounds; the coating has a yellow color near the assay; the sulfide gives also a white coating ($PbSO_3$) farther off. On being touched with the reducing flame the coating disappears, tingeing the flame azure-blue. On plaster, lead iodide coating is chrome-yellow. In solutions dilute sulfuric acid gives a white precipitate of lead sulfate; when delicacy is required an excess of the acid is added, the solution evaporated to dryness, and water added; the lead sulfate, if present, will then be left as a residue.

MARKETS - New York lead, 5.850¢; St. Louis lead, 5.700¢. (Quotations July 31, 1941)

LEAD (Continued)

POSSIBLE BUYERS

Ajax Metal Co., 48 Richmond St., Philadelphia, Pa.
American Smelting and Refining Co., Selby Smelter, Selby, Calif.
American Smelting & Refining Co., Murray, Utah.
C. M. Athey Paint Co., 500 South Hanover St., Baltimore, Md.
Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, N. Y.
Bunker Hill Smelter, Bradley, Idaho.
Camel Lead, Color & Chemical Products Mfg. Corp., 278 Green St., Brooklyn, N. Y.
Goldsmith Bros. Smelting & Refining Co., 58 East Washington St., Chicago, Ill.
International Smelting & Refining Co., Tooele, Utah.
National Lead Company, 111 Broadway, New York, N. Y.
St. Joseph Lead Co., 250 Park Ave., New York, N. Y.
U. S. Smelting, Refining & Mining Co., 57 William St., New York, N. Y.
U. S. Smelting, Refining and Mining Co., Midvale, Utah.

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E. W. Pehrson and H. M. Meyer. Lead. Minerals Yearbook (1940). pp. 107-125.

NOTES

1. Specimens of lead ores may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Cerussite, a lead carbonate, $PbCO_3$ and anglesite, a lead sulfate, $PbSO_4$ are secondary minerals which occur in the oxidized zone of lead deposits.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

APRIL - 1942

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

LIMESTONE

By
George L. Gary, Mineral Technologist

There is a wide variety of limestone ranging from pure calcium carbonate to very impure siliceous, carbonaceous, dolomitic, or ferruginous material.

PROPERTIES - Calcite ($CaCO_3$, calcium carbonate, CaO 56 percent) is found in well-defined crystals which are often very large; as crystalline crusts and druses; in cleavable or granular masses; and as stalactitic pisolitic, and oolitic forms. The cleavage is perfect rhombohedral in three directions at angles of 75°. Luster vitreous. It is usually colorless, white, or amber, but it may be any color, varying with impurities. Hardness 3. Specific gravity 2.72.

Dolomite when pure has the formula $CaMg(CO_3)_2$(calcium, magnesium carbonate) but iron usually replaces part of the magnesium and manganese in small amounts is sometimes present. It grades into ankerite, $CaCO_3(MgFeMn)\ CO_3$, a calcium, magnesium, iron carbonate which may or may not contain magnesium. The cleavage is rhombohedral like that of calcite but is often curved. Luster vitreous to pearly. Color white to reddish or greenish white; also rose red, green, brown, gray, or black. Hardness 3½ to 4. Specific gravity 2.83 to 3.00, increasing with the iron content.

OCCURRENCE - Most commercially important limestones were originally deposited on the ocean bottom as accumulations of calcareous shells along with varying quantities of impurities such as magnesium carbonate, silica, clayey material, organic matter, etc. These calcareous sediments are converted to limestone by compaction, dehydration, and crystallization.

Limestone may also be deposited from fresh water containing calcium carbonate in solution.

Commercial deposits of limestone in California are being worked in Alameda, El Dorado, Imperial, Inyo, Los Angeles, Riverside, San Bernardino, San Luis Obispo, San Mateo, Santa Clara, Santa Cruz, and Tuolumne counties.

PREPARATION - Limestone is converted to lime, also known as "quicklime", (CaO) by heating to drive off carbon dioxide gas (CO_2). The reaction is carried out in a kiln at about 1100°C and is known as calcination or burning. (For a more detailed discussion of the various types of kilns and their operation see I.C. 6884R of the United States Bureau of Mines).

Hydrated lime (calcium hydroxide, $Ca(OH)_2$) is prepared by crush-

ing calcined lime to about one inch as it comes from the kiln, slaking it, and classifying the fine powder thus produced to remove any core or overburned lime that is not slaked.

USES - Limestone and its products have a wide variety of uses, the building industries, agricultural, chemical, metallurgical, and manufacturing industries being the most important.

In addition to being used for building stone, limestone, as hydrated lime ($Ca(OH)_2$) or quicklime (CaO), is used as mortar, plaster, or masonry cement in structural work.

When used as a fertilizer, lime neutralizes the acid in the soil, replenishes the supply of calcium and magnesium, aids the growth of beneficial bacteria, improves the texture and permeability of heavy soil, hastens the decay of organic matter and the formation of nitrates, etc. (I.C. 6884).

Large quantities of limestone are used in metallurgical operations as a flux and as lime in refractory brick.

Lime is essential in the sulphite process for making paper. Other uses requiring smaller tonnages are for softening water, in the manufacture of certain kinds of glass, in treating leather, as a clarifying and purifying agent in the extraction of sugar from either beets or cane, in the manufacture of glycerine and soap, in bleaching powder (chloride of lime), etc.

TESTS - Calcite effervesces vigorously in cold dilute hydrochloric acid, and gives a wet test for calcium (see below). The action is less vigorous for the dolomitic limestones. When a powdered calcium mineral is moistened with hydrochloric acid it imparts a yellowish red color to the flame. (The strontium flame is a deeper red).

Dolomite limestones and impure limestones contain iron, magnesium and calcium. To identify these elements, dissolve some of the powdered material in hydrochloric acid and add a few drops of nitric acid to convert ferrous iron to ferric iron, then add ammonium hydroxide in excess. A brown red flocculent precipitate indicates iron (See our paper on aluminum for the distinction between ferric hydroxide (iron) and aluminum hydroxide in the same precipitate). Filter off the ferric hydroxide and to the filtrate add ammonium oxalate. A white precipitate indicates calcium. Carefully filter, and to the filtrate add more ammonium oxalate to insure complete removal of the calcium. Filter again if the solution becomes cloudy and to the filtrate add sodium acid phosphate. A white granular precipitate indicates magnesium.

MARKETS - The value of limestone depends upon its location and use and no reliable quotations can be given.

Quicklime (CaO), lump or pebble, f.o.b. San Francisco, $13.00 per ton.

Hydrated lime ($Ca(OH)_2$), in paper bags, f.o.b. San Francisco, $16.00 per ton.

(Quotations March 30, 1942).

POSSIBLE BUYERS:

Calcium Carbonate Co., 43 East Ohio St., Chicago, Ill.
Harry T. Campbell Sons Co., Towson, Md.
Carbola Chemical Co., Natural Bridge, N. Y.

POSSIBLE BUYERS (cont'd.)

Consolidated Minerals Co., P. O. Box 92, Long Island City, N. Y.
Limestone Products Corporation of America, Newton, N. J.
National Lime and Stone Co., Findlay, Ohio.
F. E. Schundler & Co., Inc., 45-15 Vernon Blvd., Long Island City, N.Y.
Smith Lime Flour Co., 286 North Broad Street, Elizabeth, N. J.
United States Lime Products Corp., 85 Second Street, San Francisco, California.
Universal Products Corp., Thornwood, N. Y.

REFERENCES:

Bowles, Oliver, Metallurgical Limestone. U. S. Bureau of Mines Information Circular 6041, June 1927.

Bowles, Oliver, and D. M. Banks. Limestone. Part I - General Information. U. S. Bureau of Mines Information Circular 6723, June 1933.

Bowles, Oliver, and D. M. Banks. Lime. U.S. Bureau of Mines Information Circular 6884R, October 1941 (Revised by Duncan McConnell).

Pabst, Adolf. Minerals of California. California State Division of Mines, Bulletin 113, 1938.

NOTES:

1. Specimens of limestone, calcite, and dolomite may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Aragonite ($CaCO_3$) is an orthorhombic calcium carbonate, whereas calcite is hexagonal-rhombohedral.

3. Other varieties of calcite are iceland spar, marble, onyx marble or "Mexican onyx" and travertine. Lithographic stone is a very even-grained compact limestone of buff or drab color.

4. Manganocalcite is a variety of calcite containing manganese. It turns black when weathered.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

JUNE - 1942

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

MAGNESITE

By
George L. Gary, Mineral Technologist

PROPERTIES - Magnesite is a magnesium carbonate, $MgCO_3$ consisting of magnesium oxide, known as "magnesia", MgO and carbon dioxide, CO_2. When pure it contains 47.6% MgO and 52.4% CO_2. It is a white, very fine-grained, compact, minutely crystalline mineral. Impure varieties are more or less coarsely crystalline in many colors - white, gray, black, pink or even red. It includes some silica, clay, serpentine and oxides of iron. Magnesite is brittle and has a conchoidal, or shell-like, fracture. The hardness varies from 3½ to 4½ and the specific gravity varies from 3 to 3.12.

OCCURRENCE - Magnesite is widespread in California because of the great areas of serpentine, of which it is an alteration product. It occurs generally as irregular veins or pockets or as massive beds or as interstratified beds like sedimentary rock. The serpentine is commonly intersected by veins and patches of snow-white to light-buff magnesite. Some of these veins and beds are commercially important. The main deposits lie in the serpentine belts of the Coast Ranges, but deposits also occur in serpentine in the foothills of the Sierra Nevada and elsewhere. Notable exceptions to these deposits in the metamorphic rocks are the sedimentary deposits at Bissell in Kern County and at Afton in San Bernardino County. A portion of the market for calcined magnesite is being supplied by magnesium oxide produced from salt-works bitterns at a plant at Newark, Alameda County, on San Francisco Bay.

PREPARATION - Magnesite is quarried from open pits or mined by tunnels and stopes, the method employed depending upon the size of the deposit and its relation to the surface. Magnesite is calcined in vertical stack kilns fired with wood, oil or coke and in rotary cylindrical kilns fired with oil or powdered coal. Caustic magnesite is the product resulting from calcining crude magnesite at a temperature of 700° to 1200° C. About 2% to 7% CO_2 is left in the product, since it has been found that a calcination temperature high enough to expel all of the CO_2 would impair the cementing properties of the magnesite. Dead-burned magnesite is the product obtained by calcining magnesite at a temperature of 1450° to 1900° C., thereby the carbon dioxide content is reduced to less than 1%, and the product remains inert in the presence of air, unlike the caustic variety which takes up carbon dioxide on exposure to air. By dispelling virtually all of the CO_2 (less than 0.5 percent) the grains are sintered to dense particles suitable for refractory purposes.

MAGNESITE (continued)

USES - The never-ending search for a light, durable, high-tensile-strength metal or alloy has led to a material increase in the production and use of the metal magnesium, as the lightest structural metal commercially available. The essential industrial use of magnesite is in metallurgy, as a refractory material for lining furnaces. There is no technically satisfactory substitute for magnesite brick. Chrome brick, however, are used for much the same purpose in other zones in the furnace linings. In the building trades the various compounds of magnesite meet the keen competition from other minerals. In the near future it may well be that the market for magnesium metal may increase materially. This suggestion is based upon the fact that the present trends are toward reduction in weight for such commodities as cars, buses, trucks, trailers, airplanes, and portable equipment, and magnesium metal or an alloy may well meet this trend. Should this development take place, keen competition between aluminum, and magnesium, as well as special high-strength alloy steels, will result. Magnesium is one-third lighter than aluminum, and although the volume of production is still small it has become one of its chief competitors. In the manufacture of stucco, plaster boards, and such building materials as base-coat, sanded, finished, and molding plasters, plasterboard and lath, wallboard, partition tiles, and insulating materials, magnesite has many competitors among which it would be difficult to choose substitutes.

TESTS - Magnesite is not acted upon by cold dilute hydrochloric acid but dissolves readily with effervescence in hot acid. If the solution is made strongly alkaline with ammonia, and sodium phosphate added, a white crystalline precipitate will be formed. Before testing, however, it must be ascertained whether other substances are present which would tend to form a precipitate. A good procedure is as follows: Dissolve a very small portion of the mineral in a small quantity of boiling hydrochloric acid, add a drop or two of nitric acid and then water, and again heat to boiling. Add ammonia in excess, and filter if there is a precipitate. To the filtrate add ammonia oxalate and again filter if there is a precipitate. Then add sodium phosphate and as noted above a white crystalline precipitate indicates magnesium.

MARKETS - Per ton, f.o.b. California, dead-burned, $32. Artificial periclase, 94 per cent MgO, $65; 90 percent $35. Caustic, 95 percent MgO, white color, $40; 85 percent MgO, no color standard, $37.50. Washington: Dead-burned grain magnesite, $22. (Quotations May 21,1942).

POSSIBLE BUYERS

American Cyanamid & Chemical Corp., 30 Rockerfeller Plaza, New York, N.Y.
Bradley & Ekstrom, 320 Market Street, San Francisco, California.
Leonard J. Buck, Inc., 1 Newark Avenue, Jersey City, N. J.
C.B.R. Fitz-Williams and Company, Ltd., 904 Security Building, St. Louis, Missouri.
Magnesite Products Co., Ray Building, Oakland, California
Schofield-Donald Co., Inc., 154 Nassau Street, New York, N. Y.
The Warner Chemical Co., 405 Lexington Avenue, New York, N. Y.
Westvaco Chlorine Products Co., Newark, California.
Whittaker, Clark & Daniels, Inc., 260 West Broadway, New York, N. Y.
Wishnick-Tumpeer, Inc., 295 Madison Avenue, New York, N. Y.

MAGNESITE (continued)

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Walter W. Bradley: Magnesite in California. California State Division of Mines. Bulletin 79 (1925).
C. F. Floe: Magnesium Metal from Washington Magnesite and Dolomite Deposits. State College of Washington Met. Research Bur. Bulletin B (1934).
Herbert A. Franke and M. E. Trought: Magnesium. Minerals Yearbook, (1940), U. S. Bur. Mines, 717-725.
F. L. Hess: The Magnesite Deposits of California. U. S. Geological Survey Bulletin 355 (1908).
J. S. McDowell and R. M. Howe: Magnesite Refractories. Jnl. Amer. Ceramic Soc. (March 1920) 3, 185-246. This is a good general treatise on magnesite occurrences, mining and utilization.
Adolf Pabst: Minerals of California. Bulletin 113. California State Division of Mines. 1938.
O. C. Ralston, R. D. Pike and L. H. Duschak: Plastic Magnesia. U. S. Bur. Mines Bulletin 236 (1925).
P. M. Tyler: Magnesite. U. S. Bur. Mines Inf. Circ. 6437 (May 1931).

NOTES

1. Specimens of magnesite may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. The demand for magnesite greatly increased during the European War, 1914-1918, because of its extensive use for refractory linings in all kinds of smelting furnaces, and because of its numerous other applications which made it indirectly of great value as a war mineral. As a refractory it is a substitute for chromite. It thus released much of the latter mineral for use in the manufacture of steel.

3. Other magnesium minerals of commercial value are dolomite and brucite which will be covered in other papers in this series In addition, there are more than 100 magnesian minerals occurring either in small amounts or in such chemical combinations as not to be economically recoverable at the present time.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | NOVEMBER - 1941 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

MAGNESIUM

By
George L. Gary, Mineral Technologist

Raw materials from which economic extraction of magnesium is feasible include magnesium chloride derived from sea and lake water, underground brine, and salt, potash and other saline operations; and magnesium oxide derived from magnesite, brucite and dolomite.

PROPERTIES - Brucite (magnesium hydroxide, $Mg(OH)_2$, 41.6 percent magnesium) is usually found in foliated masses and fibrous seams. The cleavage is in one direction, color white or greenish white, luster pearly or silky, hardness $2\frac{1}{2}$, specific gravity 2.4.

Magnesite (magnesium carbonate, $MgCO_3$, 28.7 percent magnesium) occurs in cleavable or compact porcelain like masses. Rhombohedral cleavage is sometimes prominent. The color is usually white or gray but it may be reddish or brown. The luster is dull, hardness 4 to $5\frac{1}{2}$, specific gravity 3.0 to 3.3.

Dolomite (calcium magnesium carbonate $CaMg(CO_3)_2$, 21.7 percent magnesium) is found as crystals, in cleavable masses, and in granular and massive forms. The cleavage is rhombohedral like that of calcite but is often curved. The color is white, pink or gray, luster pearly to vitreous, hardness $3\frac{1}{2}$ to 4, specific gravity 2.8 to 3.0.

Carnellite (hydrous potassium magnesium chloride $KCl.MgCl_2.6H_2O$) occurs massive or granular. It is very deliquescent and has a bitter, saline taste. The fracture is conchoidal, it is colorless to reddish, luster vitreous, hardness 1, specific gravity 1.6.

OCCURRENCE - Magnesite occurs abundantly, but generally in small deposits, in the California Coast Ranges, where it may be found as irregular pockets principally as an alteration product in serpentine. It also occurs as bedded deposits due to the replacement of limestone or dolomite, or the direct deposition of magnesium carbonate.

Magnesite is found in 23 counties in California. In addition to the Coast Range deposits there are two important sedimentary deposits; one near Bissel, Kern County, and the other at Afton, San Bernardino County. Recent shipments have come from Imperial, Santa Clara, and Stanislaus counties.

MAGNESIUM (Continued)

There is no recorded production of brucite in California although it has been observed in Riverside and San Francisco counties.

Brucite occurs in a deposit of commercial importance on the western slope of Paradise Range in northwestern Nye County, Nevada.

Beds of dolomite or dolomitic limestone are common in sedimentary deposits. Dolomite is often associated with serpentine and other magnesian rocks, in which it may be found as white veins.

The most important occurrences of dolomite in California and the sources of recent shipments are in Inyo, Monterey, and San Benito counties. It is found in thirteen counties in all.

There are no reported occurrences of carnellite in California. It occurs in salt beds associated with anhydrite, halite, sylvite, and kainite.

USES - There is a growing demand for magnesium in industry due to the gradual realization of the excellent properties of the metal and a constant improvement in the technique of production and fabrication.

Magnesium weighs about one-third less than aluminum (specific gravity of magnesium 1.74; specific gravity of aluminum 2.70). Its tensile strength is slightly less than that of aluminum and it is more subject to corrosion. Magnesium-base alloys when properly heat treated and aged develop tensile strengths that compare favorably with those of aluminum alloys. These alloys are malleable and ductile and can be machined more readily than any other structural metal.

The aircraft industries consume about 80 percent of the structural magnesium-base alloys produced for use in engines, fuselage, wings, and wheels. (Magnesium-base alloys contain about 85 percent magnesium.) The automobile, high-speed tool, textile and other industries consume about 20 percent of the output.

Before the value of magnesium alloys for structural purposes was recognized, the metal was used as a deoxidizer in nonferrous metallurgy, a constituent of aluminum alloys, in ammunition, and in flares.

PREPARATION - Domestic supplies of magnesium are obtained from underground brine at Midland, Michigan, from sea water at Freeport, Texas, and from magnesium oxide at the Todd-California Shipbuilding Company's plant at Permenente, 15 miles northwest of San Jose, Calif.

The larger part of the world output of magnesium is produced by the electrolysis of fused magnesium chloride.

The more recent method of direct electro thermal reduction was developed by Dr. Fritz J. Hansgirg and is now being used at Permenente. Magnesia (MgO) and carbon are heated at temperatures above 1900°C., and the resulting mixture of magnesium and carbon monoxide (CO) is cooled to 200°C., rapidly and in the absence of oxygen. This is done by chilling and condensing the vapor in a

chamber filled with methane (CH_4). The resulting impure magnesium is purified by distillation. In a pilot plant, the U. S. Bureau of Mines is employing a spray of hydrocarbon oil to chill and condense the magnesium vapor. The magnesium and oil are then separated by distillation.

TESTS - Magnesite is usually distinguished by the compact white masses, but some varieties show good cleavage and are distinguished by the relatively high specific gravity. It may be necessary to prove that calcium is not an essential constituent. It is infusible.

Brucite is soluble in HCl. It yields water in the closed tube.

Dolomite is infusible and colors the flame yellowish red. The iron-bearing varieties darken in the closed tube and also become magnetic when heated in a reducing flame on charcoal. Large fragments are only slightly attacked by cold dilute HCl. In solutions, sulfuric acid gives a white crystalline precipitate.

Carnellite is distinguished by its bitter taste and lack of cleavage. It is soluble in water.

Magnesium may be identified in the presence of NH_4OH and NH_4Cl. Upon addition of Na_2HPO_4, $NH_4 MgPO_4.6H_2O$ is precipitated slowly. The solution should be cold. Other metals (except alkalies) must be absent as they also give precipitates.

MARKETS - Magnesium metal - Per pound ingots, (4 x 16 inches) 99.8 percent carload lots, 22½c; 100 lbs. or more, less than carload, 24½c. Extruded sticks, carload lots, 29½c; 100 lbs. or more, less than carload, 31½c (Quotations May 21, 1942).

Magnesite Per ton, f.o.b. California, dead burned, $32. Artificial periclase, 94 percent MgO, $65; 90 percent $35. Caustic, 95 percent MgO, white color, $40; 85 percent MgO, no color standard, $37.50. Washington: Dear burned grain magnesite, $22. (Quotations May 21, 1942).

POSSIBLE BUYERS - Since the raw materials for magnesium have a variety of uses as compounds, possible buyers other than those producing magnesium metal are also listed.

Magnesite

Bradley & Ekstrom, 320 Market Street, San Francisco, California
Leonard J. Buck, Inc., 1 Newark Avenue, Jersey City, N. J.
Harry H. Davidson, 17 State Street, New York, N. Y.
General Magnesite & Magnesia Co., 2960 East Venango St., Philadelphia, Pa.
Goldwynne Magnesite & Magnesia Corp., 420 Lexington Ave., New York, N.Y.
Hachmeister & Lind Chemical Co., Pittsburgh, Pa.
Innis, Speiden & Co., 117 Liberty St., New York, N.Y.
Mitsui & Co., Ltd., Empire State Building, New York, N. Y.
F. E. Schundler & Co., Inc., 620 Railroad St., Joliet, Ill.
Sicklick & Company, Ltd., 40 East 49th St., New York, N. Y.
Speiden Whitfield Co., Inc., 150 Nassau St., New York, N. Y.
The Warner Chemical Co., 405 Lexington Avenue, New York, N. Y.
Whittaker, Clark & Daniels, Inc., 260 West Broadway, New York, N. Y.
Wishnick-Tumpeer, Inc., 295 Madison Avenue, New York, N. Y.

MAGNESIUM (Continued)

Magnesium hydroxide (Brucite)

J. T. Baker Chemical Co., Phillipsburg, N. J.
California Chemical Co., Div. Westvaco Chlorine Products Corp., 405 Lexington Ave., New York, N. Y.
Mallinckrodt Chemical Works, St. Louis, Mo.
Marine Magnesium Products Corporation, South San Francisco, Calif.
Merck & Co., Inc., Rahway, N. J.
Meyer Magnesia Co., 153 No. Dearborn Ave., Kankakee, Ill.
G. S. Robins & Co., 126 Chouteau Ave., St. Louis, Mo.
Schofield-Donald Co., Inc., 88 Shipman St., Newark, N. J.
The Warner Chemical Co., 405 Lexington Ave., New York, N. Y.
Whittaker, Clark & Daniels, Inc., 260 West Broadway, New York, N. Y.

Magnesium Metal

Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, N. Y.
The Dow Chemical Co., Midland, Michigan.
Golwynne Magnesite & Magnesia Corp., 420 Lexington Ave., New York, N. Y.
Metallurgical Products Co., 35th and Moore St., Philadelphia, Pa.
F. Rudloff, 59 Pearl St., New York, N. Y.

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NOTE

Specimens of magnesium may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

SEPTEMBER - 1942

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

MANGANESE

By
George L. Gary, Mineral Technologist

PROPERTIES - The most important ores of manganese are psilomelane and pyrolusite, the two minerals often occurring together and quite frequently in alternating layers. They are generally associated with limonite, the common yellow oxide of iron. Psilomelane is essentially manganese dioxide and manganese monoxide with some combined water, barium oxide and small amounts of iron. It is massive and botryoidal, or grape-like, in structure. It is iron-black or dark steel-gray in color, and gives a brownish black streak. The hardness is 5-7; the gravity varies from 3.3 to 4.7. Pyrolusite is a black mineral, which is usually sooty and soft enough to soil the fingers when handled. Its chemical composition is manganese dioxide, MnO_2, but like all ores it contains some impurities such as silica, iron and lime. It is usually columnar, often divergent and granular massive in structure. It is iron-black, dark steel-gray, sometimes bluish in color, and gives a black or bluish black streak. The hardness is 2 - 2.5, much softer than psilomelane; the gravity varies from 4.73 - 4.86.

OCCURRENCE - Nearly all commercial manganese deposits are of secondary formation; that is, they are concentrated from manganese minerals more sparsely distributed in rocks. Some manganese occurs in soft gravel or clay formations, but in other places the mineral is found in the form of veins and rounded nodules in limestone and hard rock. Manganese occurs in irregular masses with smooth surfaces in jasper in the Coast Ranges and in slates, shales and igneous rocks of the Sierra Nevada. The majority of the manganese deposits of California are located in the Coast Ranges. They are widely distributed from Siskiyou County, southerly through Trinity, Humboldt, Tehama, Mendocino, Glenn, Lake, Sonoma, and Napa Counties. Further south there is a prominent belt including the easterly portion of Alameda, Santa Clara and San Benito counties and the westerly portion of San Joaquin, Stanislaus and Merced counties. There are several deposits in the northwestern part of San Luis Obispo County. In the foothills of the Sierra Nevada there are numerous deposits, principally in Plumas, Butte, Yuba, Nevada, El Dorado, Amador, Calaveras and Tuolumne counties. A few properties are located in San Bernardino, Riverside, Imperial and Kern counties.

CLASSIFICATION - Manganese ore comprises four different raw materials, determined by grade and quality as follows:

1. Exceptionally high-grade manganese ore characterized by a high content of MnO_2 is used in making batteries. It commands the highest unit price and is known as battery ore, or chemical ore.

2. At the other extreme is manganiferous iron ore, usually containing 10 percent or less manganese; it is used for making manganiferous pig iron. The domestic supply of such ore is so abundant that the manganese it contains is usually paid for as if it were iron.

Between these two extremes are the ores low in iron that are suitable for making ferromanganese and those high in iron used for making spiegeleisen, although some of it is used for making pig iron.

3. For making ferromanganese, the ore usually contains at least 45 percent manganese but averages 48 percent, and the ratio of manganese to iron is not less than 7 to 1 though it usually is 8 to 1, while there must be low silica, ranging from 7 to 10 percent and very low phosphorus, ranging from 0.12 to 0.2 percent. Only manganese ore of this character has been designated as a strategic mineral because domestic production is inadequate.

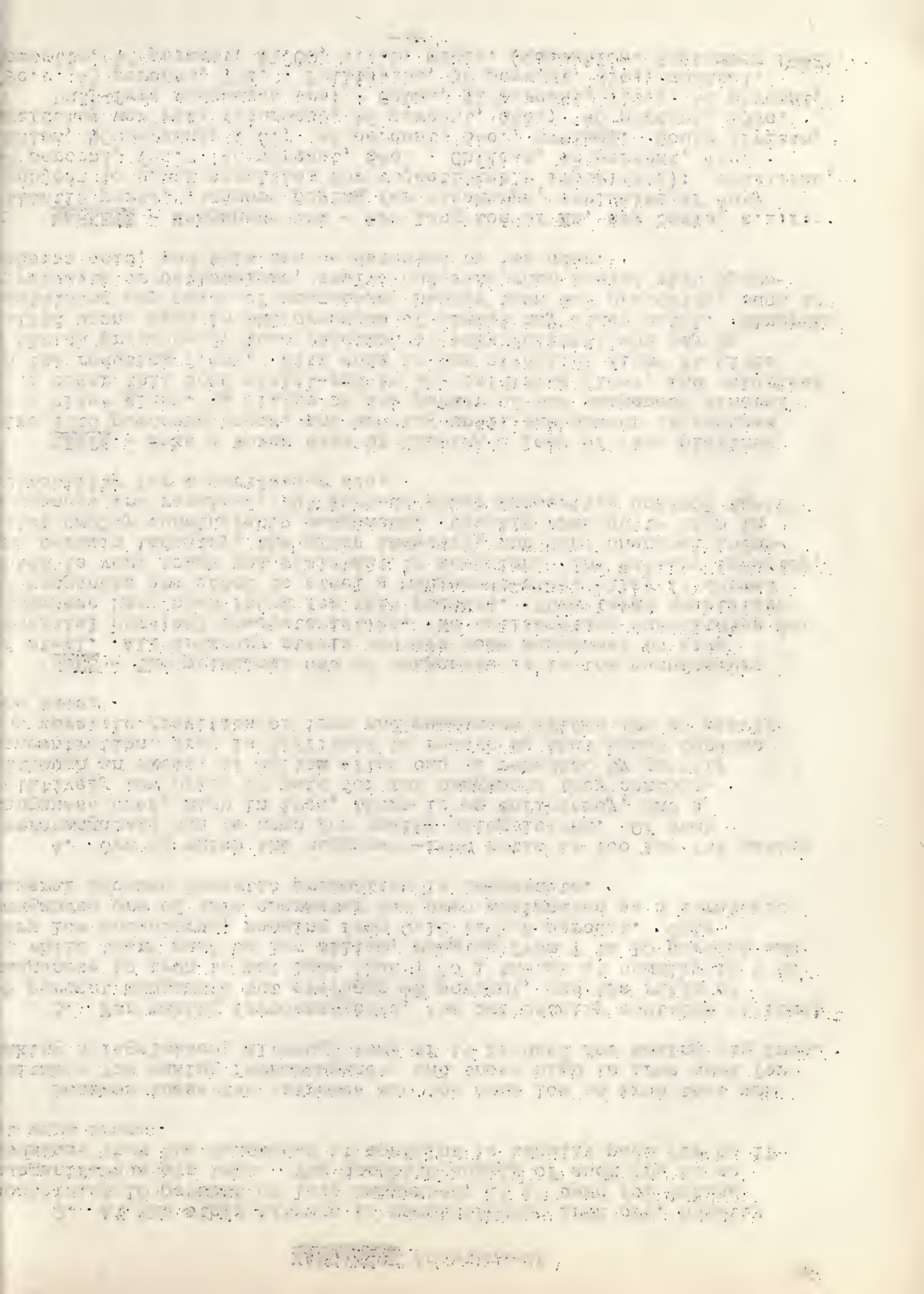
4. Ore in which the manganese-iron ratio is too low for making ferromanganese can be used for making spiegeleisen. Of such manganese ores, high in iron, there is no deficiency, and a relatively low price is paid for the manganese they contain. Although an excess of silica often can be remedied by gravity concentration, iron is difficult to remove by that means because the specific gravities of iron and manganese oxides are so nearly the same.

USES - The principal use of manganese is in the manufacture of steel. All ordinary steels require some manganese to give essential physical characteristics. No satisfactory substitutes for manganese have been found for this purpose. When large quantities of manganese are added to steel a manganese-steel alloy is formed which is very tough and resistant to abrasion. The battery industry, the ceramic industry, the glass industry, and many chamical industries employ considerable manganese. Usually ores quite high in manganese are required, but various other properties control their suitability for a particular use.

TESTS - Make a borax bead by dipping a loop of fine platinum wire into powdered borax, and heating until the powder is reduced to a clear glass. A little of the powder of the manganese mineral will cover this bead violet-red in the oxidizing flame, and colorless in the reducing flame. With soda in the oxidizing flame it gives a bluish green bead; this reaction is very delicate and may be relied upon, even in the presence of almost any other metal. Minerals containing any oxide of manganese, higher than the protoxide, such as pyrolusite or psilomelane, evolve chlorine when heated with hydrochloric acid, and this can be detected by its odor.

MARKETS - Manganese Ore - Per long ton of Mn, dry basis, c.i.f. Atlantic ports, steamers paying for discharge, exclusive of duty (subject to usual penalties for objectionable impurities): Brazilian, 48 percent, 65c.; 46 percent, 64c. Chilean, 48 percent, 68c. Indian, 50 percent, 66c.; 48 percent, 64c., nominal. South African, excluding war risk insurance, 48 percent, 65c.; 46 percent, 63½c.

Duty-free manganese ore: - Cuban, 51 percent, 81c.; 48 percent, 79c.; 45 percent, 75c. Philippine, 50 percent, 81c., nominal. Domestic, 48 percent, $1.00, f.o.b. mines. (Quotations September 1942).



MANGANESE (continued)

POSSIBLE BUYERS

American Manganese Corp., Box 629, Torrence, Calif.
Bethlehem Steel Corp., 20th & Illinois Sts., San Francisco, Calif.
Bradley & Ekstrom, 320 Market St., San Francisco, Calif.
Colorado Fuel & Iron Co., Pueblo, Colo.
Columbia Steel Co., Russ Building, San Francisco, Calif.
Electro-Metallurgical Co., 30 East 42nd St., New York, N. Y.
Foote Mineral Co., 1609 Sumner St., Philadelphia, Pa.
General Dry Batteries Inc., 13000 Athens Ave., Cleveland, Ohio
W. R. Grace & Co., 7 Hanover Square, New York, N. Y.
Chas. Hardy, Inc., 122 E. 42nd St., New York, N. Y.
E. J. Lavino & Co., Bullitt Bldg., Philadelphia, Pa.
Metals Reserve Co., Washington, D. C.
Ore, Metal & Engineering Corp., 112 Market St., San Francisco, Calif.
Henry Rising & Co., 626 St. Paul Ave., Los Angeles, Calif.
U. S. Vanadium Corp., 114 Sansome St., San Francisco, Calif.
Vance & Barnes, Ltd., 1131 Park Ave., Alameda, Calif.

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Walter W. Bradley, Emile Huguenin, C. A. Logan, W. B. Tucker and C. A. Waring: Manganese and Chromium in California. California State Division of Mines Bull. 76 (1918).

G. H. Chambers: Manganese. Industrial Minerals and Rocks, (1937). The American Institute of Mining and Metallurgical Engineers. An excellent treatise on the uses of manganese outside of the metallurgical field.

R. S. Dean, Fred D. DeVaney and Will H. Coghill. Manganese -- Its Occurrence, Milling and Metallurgy. Part I. U. S. Bureau of Mines Inf. Circular. 6768 (May 1934).

C. G. Maier. Manganese -- Its Occurrence, Milling and Metallurgy. Part II. U.S. Bur. Mines Inf. Circular 6769 (May 1934).

R. S. Dean, Edmund S. Leaver and T.L. Joseph. Manganese -- Its Occurrence, Milling and Metallurgy. Part III. U. S. Bur. Mines Inf. Circ. 6770 (May 1934).

G. R. Fitterer and M. B. Royer. Manganese -- Its Occurrence, Milling and Metallurgy. Part IV. U.S.Bur. Mines Inf. Circ. 6771 (May 1934).

Mabel E. Winslow. Manganese -- Its Occurrence, Milling and Metallurgy. Part V. U. S. Bur. Mines Inf. Circ. 6772 (May 1934).

R. H. Ridgway and H. W. Davis: Manganese and Manganiferous Ores. Minerals Yearbook (1940). U.S.Bur. Mines, 571-589.

NOTES

1. Specimens of manganese ores may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Other manganese minerals of minor commercial value are manganite, hausmannite, braunite and rhodochrosite.

3. Prices of manganese ores and specifications for different grades are changing monthly. The Division of Mines will be glad to furnish new prices and specifications upon request.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | MAY - 1941 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

MICA

By
George L. Gary, Mineral Technologist

PROPERTIES - Strictly speaking, "mica" is not the name of a mineral, but a group name for a number of aluminum silicate minerals all of the same general type and characterized by their high reflection and a basal cleavage so perfectly developed that they can be split into exceedingly thin laminae, which are more or less tough, elastic, and transparent, according to variety. Five species of mica are commercially important, muscovite, biotite, phlogopite, lepidolite and roscoelite; of these muscovite, biotite and phlogopite are used solely because of their physical properties, whereas lepidolite and roscoelite are mined as ores of lithium and vanadium respectively. Of these five minerals, muscovite, or potash mica, $H_2KAl_3(SiO_4)_3$ is the most important mica of commerce. It usually occurs in cleagages and scaly masses; sometimes as tabular crystals, hexagonal or rhombic in outline, with vertical faces rough and striated. Thin laminae of muscovite are transparent, flexible, elastic, and usually colorless. Sheets 1/8 inch or more in thickness, however, usually show a distinct color - some shade of gray, brown, yellow, or green. The streak is colorless and the luster vitreous to more of less pearly or silky. The hardness is 2 - 2.5 and the specific gravity 2.76 - 3.

OCCURRENCE - Muscovite is the most common of the micas; as an essential constituent in all granites, gneisses, schists, and other related rock it occurs in hugh quantities. However, it rarely has commercial value in these forms as it usually cannot be recovered economically. A few schists exceptionally rich in muscovite (or sericite, a fine scaly muscovite united in fibrous aggregates and characterized by its silky luster) are milled for their mica content. With these exceptions all commercial muscovite is derived from pegmatites, the sole source of sheet mica the world over. Pegmatites have been defined as "rocks with coarsely and unevenly crystallized and segragated minerals occuring as dikes, veins, or metamorphic masses formed from the aqueous solutions of a freezing magma or from the combination of the solutions with previously existing minerals". Phlogopite is a scarce mineral compared with muscovite, although it is quite abundant in some regions of contact metamorphism. However, so far as known, there are but few areas in the world in which commercial deposits of sheet phlogopite occur - the Privinces of Quebec and Ontario, Canada, eastern Madagascar, and Russia. Extensive areas of mica-schists occur in California, in which muscovite is a principal constituent and gives the rock its schistose structure; some muscovite and sericite are commercially produced.

MICA (continued)

PREPARATION - After a preliminary sorting at the mine, discarding all material unsuitable for the production of sheets, the rough mica goes to the cobbing shed, where the crystals or "books" are cleaned of adhering rock and split into sheets. The next step is the trimming of the sheets to facilitate further splitting, as well as to remove the imperfections. The trimmed sheets are known as "uncut" or "unmanufactured" sheet mica, and are mostly sold in this form, although some producers carry the operations through the final stage of cutting the sheet to standard market sizes and shapes, giving what is known as "cut" sheet which is classified as to quality and graded for size. The scrap produced in trimming sheets is available for punch mica, splittings and ground mica.

USES - The chief uses for mica center around its high insulating and dielectric properties, inertness to high temperatures, low heat conductivity, flexibility, cleavage, toughness, and transparency. There are three main commercial classes. Sheet mica, including punch, splittings and scrap. Sheet mica is used chiefly for electrical purposes and glazing; splittings are made into built-up mica; scrap is ground to a powder. Specific uses of mica may be found in the information circular on "Mica" listed in the bibliography.

TESTS - The micas are easily distinguished by their perfect cleavage; thin laminae flexible and elastic when bent, very tough, harsh to the touch, passing into kinds which are less elastic and have a more or less unctous or talc-like feel. Muscovite in the closed tube gives water. Before the blowpipe it whitens and fuses on the thin edges to a gray or yellow glass. With fluxes gives reactions for iron and sometimes manganese. Not decomposed by acids. Decomposed on fusion with alkaline carbonates.

MARKETS

Mica, per ton, f.o.b. New Mexico, scrap, white, $16; off color, $12. Punch, white, for disks, per lb. 12¢ for washers 10¢.

Per ton, f.o.b. New Hampshire, roofing mica, $23; snow, $35; 40 mesh white, $40; 60 mesh, $48; 100 mesh $60; 200 mesh, $75. Clean dry mixed bench and mine scrap, $16.00 @ $18.00.

Per lb. f.o.b. North Carolina: Punch 8 @ 15¢; 1½ x 2 in.; 45 @ 60¢; 2 x 2, 60 @ 80¢: 2 x 3, 90¢ @ $1.20; 3 x 3, $1.25 @ $1.50; 3 x 4, $1.50 @ $1.75; 3 x 5, $1.75 @ $2.25; 4 x 6, $2.75 @ $3.50; 6 x 8, $4.25 @ $4.75; 8 x 10, $8.50 @ $8.75. The above prices apply to No.1 and No.2 quality stock. Stained qualities take from 25 to 35 percent discount. White North Carolina mica, 70 mesh, $60 to $80 per ton. Biotite, or black mica, $15 per ton underground. White, Georgia, 300 mesh, $20.00; ground roofing, 20 mesh, $18; sericite, 300 mesh, $15; mica schist, 20 mesh, $16.00. (Quotations, May 1941).

Title Omitted

PREPARATION - Allow a preliminary exposure to dim rays, dissolve [illegible] mucilage for the ephedra and cover. Use rough [illegible] to the bobbing head, close the openings or "ports" [illegible] of watering rock and split into quarts. Use cork [illegible] of the drops to fragrant formula [illegible] or roll a [illegible] the impositions. The desired check are known as "stars" [illegible] "natural" effect rods, and are mostly used in well [illegible] through rust process carry the overflows through the [illegible] under the sheet to standard aerated clips and ammon. Keeping want [illegible] my dusty sheet which is classified as to quality and spelled [illegible]. The empty produced in turning clears is available for [illegible] uplifting and pressed wire.

USES - The chief uses for rice center around its [illegible] [illegible] and digestible proteins, its value as high carbohydrate, [illegible] heat conductivity, thermity, insulating, and [illegible] impermeability. There are three main commercial classes. Short grain, [illegible] purple, and long. Short grain is used chiefly [illegible] puddings and desserts; [illegible] are used into [illegible] dishes, curry is served to a crowd. Specific uses of this [illegible] in the [illegible] climate on which it fed in the [illegible].

ITEMS - The rules are easily distinguished by their general [illegible] this Jersey Digital are clearly shown here, very tough, [illegible] to the touch, and the [illegible] are less elastic and [illegible] type a wire on less unsound or [illegible]. Moisture in the [illegible] type dries water. Extra the bicycle it utters and lines on [illegible] adds to a dry or [illegible]. Wait these cord vacation [illegible] and sometimes sometimes. Mix decomposed by acids. Decomposed [illegible] with alkalis reagents.

[illegible]
[illegible] Inc. Inc. Co., Blue Ridge, Aurora, white, Blk, oil color, [illegible] Pencil, white, Tee Clubs, Inc. Ltd., Key Western Inc.
For Sale, 1 Co., Mar Engraving, Woolen Plan, Mail; Lens, Corp. [illegible] Co. Wash, Corp. of Real, Wash., Inc. Inc. Corp. Blue, Clear [illegible] Beach and Rice Farms, Wash. Co. & Ltd. Co.
For Inc., Inc., Real Corporation, Inc. Inc. & Co., Inc. Co., Inc. [illegible]
[illegible]
[illegible]
[

MICA (continued)

POSSIBLE BUYERS

Ground Mica

American Rubber Mfg. Co., Park Ave. and Watts St., Oakland, Calif.
Paraffine Co., Inc., 475 Brannan St., San Francisco, Calif.
Samson Tire and Rubber Co., 5725 Telegraph Road, Los Angeles, Calif.
Standard Oil Co. of California, 225 Bush St., San Francisco, Calif.

Sheet Mica and Splittings

Ford Radio & Mica Corp., 832 - 4th Ave., Brooklyn, N. Y. (uncut).
General Electric Co., 1 River Road, Schenectady, N. Y.
Mica Insulator Co., 200 Varick St., Brooklyn, N. Y.
Reliance Mica Co., 342 - 39th St., Brooklyn, N. Y.

Mica and Sericite

Pacific Minerals Co., Ltd., Richmond, California.

Scrap Mica

Standard Oil Co. of Indiana, 910 S. Michigan Ave., Chicago, Ill.
Industrial Minerals Corp. of America, 220 Delaware Ave., Buffalo, NY. (also punch)

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F.W.Horton. Mica. U.S.Bureau of Mines Information Circular 6822 (April 1935).
Adolf Pabst. Minerals of California. California State Division of Mines Bulletin 113 (1938).
G. A. Roush. Strategic Mineral Supplies. McGraw-Hill Book Co., New York, N. Y.
Paul M. Tyler and K. G. Warner. Mica. Minerals Yearbook. 1940. U.S.Bureau of Mines, pp 1403-1419.

NOTES

1. Specimens of mica may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. A number of micaceous minerals known as vermiculites are found in California. They are all hydrated silicates, in part closely related to the chlorites and are alteration products of the micas. The vermiculites are expanded by heating and used as insulating agents for both heat and sound. A small amount of this material has been commercially produced in California.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley State Mineralogist	AUGUST - 1941	Ferry Building San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

MOLYBDENUM

By
George L. Gary, Mineral Technologist

PROPERTIES - The sulfide molybdenite, MoS_2 is the most common and principal ore mineral of molybdenum. It is found commonly foliated, massive or in scales; also fine granular. The laminae are very flexible but not elastic. It is sectile and has a greasy feel. The luster is metallic; streak grayish black, color lead-gray. The hardness is 1-1½ and the gravity is 4.62 - 4.73. The lead molybdate wulfenite, $PbMoO_4$ is also an ore of molybdenum. It occurs commonly in square tabular crystals, sometimes extremely thin; also granular massive, coarse to fine, firmly cohesive. Brittle. Luster vitreous to adamantine. Streak white; color yellow, orange, red, gray, white. The hardness is 3 and the gravity 6.7 - 7.

OCCURRENCE - Molybdenite forms as an accessory mineral in certain granites; in pegmatites and aplites. Commonly in vein deposits associated wity cassiterite, scheelite, wolframite and fluorite; also in contact metamorphic deposits with lime silicates, scheelite and chalcopyrite. Wulfenite is found in the oxidized portion of lead veins with other secondary lead minerals, especially vanadinite and pyromorphite. Molybdenite is widely distributed in California, occurring in small flakes and leaves in quartz veins and granites. Wulfenite in small grains and crystals occur in California, the principal occurrences being in Inyo and San Bernardino counties.

PREPARATION - Molybdenite can be concentrated readily by flotation methods. An ore carrying less than 1 percent can be concentrated to a product carrying 60 or even 70 percent molybdenite. Usually mixtures of kerosene and pine oil are used, although othte oils give satisfactory results on other ores. As ferromolybdenum, which is the chief use of molybdenum, can be made directly from molybdenite concentrates, it is not necessary to treat molybdenite chemically unless molybdic oxide or ammonium molybdate are required for chemical purposes. Wulfenite can be concentrated by ordinary milling methods, using tables and slimers.

State of California
Department of Natural Resources

DIVISION OF MINES

[illegible]	REPORT - 1941	[illegible]

DIVISION OF MINES AND MINING
(Ferry Bldg.)

REPORT

on

Geology of Portions of Nevada, Inyo, and Mono Counties

by

Olaf P. Jenkins, Chief Deputy Mineralogist

INTRODUCTION - The region described in this report comprises approximately 7,000 square miles in the eastern part of California. It is known commonly as the Great Basin region, or as the Nevada desert country. The mountains are generally of the fault-block type, and the valleys are typically long, narrow, flat-floored troughs. The highest point is Boundary Peak (13,145 feet), and the lowest is Death Valley (-279 feet). The land surface is accessible by automobile over numerous highways and roads, and by pack animal over many trails. Supplies may be obtained at Bishop, Big Pine, Independence, Lone Pine, Olancha, Keeler, Darwin, Trona, Ridgecrest, Randsburg, Johannesburg, Inyokern, Mojave, Owenyo, and Benton. Gasoline is available at Lone Pine, Olancha, Keeler, Darwin, Trona, Ridgecrest, Randsburg, Johannesburg, Inyokern, Mojave, and Benton.

GEOMORPHOLOGY - The physiographic forms of the region are typical of the Great Basin province: the mountains are tilted and uplifted fault blocks, and the valleys are structural troughs, modified by erosion and deposition. Mountains rise abruptly from the valley floors, and the valleys are filled with coarse alluvial material, especially at the mouths of the canyons. Alluvial fans are widely developed in the valleys. Numerous playas, or dry lakes, are found in the lowest parts of the valleys. Underflow in the alluvial deposits and springs issuing from the rocks at the foothills provide water for irrigation and domestic purposes in Inyo and Owens Valleys.

USES - Molybdenum is used chiefly as an alloy, both alone and with other ferroalloying elements in iron and steel. Its chief use is to replace part of the tungsten in high-speed tool steels, thus increasing the toughness of the steel. Molybdenum steels are used extensively in the automotive, oil and aircraft industries. In the form of ammonium molybdate, molybdenum is used as a chemical reagene, as a fireproofing material, and as a disinfectant. Molybdenum compounds are also used to color leather and rubber, and to a limited extent in the ceramic industry.

TESTS - On charcoal molybdenum sulfide gives near the assay a copper-red stain (oxidizing flame), and beyond a white coating of the oxide; the former becomes azure-blue when for a moment touched with the reducing flame. The iodide coating on plaster is deep ultramarine blue. The salt of phosphorus bead (oxidizing flame) is yellowish green (hot) and nearly colorless (cold); also (reducing flame) a fine green. Molybdates are tested by putting powdered mineral in dry test tube with small scrap of paper, adding a few drops of water and an equal amount of concentrated sulfuric acid. Heat until acid fumes. Cool and add slowly drops of water and solution will assume deep blue color.

MARKETS - Molybdenum. Per lb., 99 percent, $2.60 @ $3.00. Molybdenum ore. Per lb. of contained MoS_2, 90 percent concentrate, 45¢, f.o.b. mines. (Quotations July, 1941).

POSSIBLE BUYERS

Clifford L. Ach, 2309 East 8th St., Los Angeles, California
Arizona Molybdenum Corp., 433 So. Spring Street, Los Angeles, Calif.
Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, N. Y.
Climax Molybdenum Company, 500 Fifth Avenue, New York, N. Y.
Fansteel Metallurgical Corp., North Chicago, Ill.
The Molybdenum Corp. of America, 500 Fifth Avenue, New York, N. Y.
United States Vanadium Corp., 114 Sansome Street, San Francisco, Cal.

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Adolf Pabst. Minerals of California. California State Division of Mines Bulletin 113. (1938).
Robert H. Ridgway and N. W. Davis. Molybdenum. Minerals Yearbook (1940), pp 617-623.

NOTES

1. Specimens of molybdenum ores may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Ferrimolybdite, $Fe_2O_3.3MoO_3.8H_2O$, occurs commonly in small amounts as an oxidization product of molybdenite.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | APRIL - 1942 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

MONAZITE AND ALLANITE

By
George L. Gary, Mineral Technologist

There are fifteen rare earths of which only cerium and its salts are of commercial value.

PROPERTIES - Monazite $(Ce,La,Pr,Nd)PO_4$, a phosphate of the rare earths cerium, lanthanum, praseodymium and neodymium, usually with some thorium silicate, is commonly found in grains as sand. Brittle. Vitreous to resinous luster. Color yellowish brown but sometimes reddish. Hardness 5 to 5½. Specific gravity 5.0 to 5.2.

Allanite or orthite $(Ca,Fe,)_2(AlOH)(AlCeFe)_2(SiO4)_3$ basic calcium, iron, aluminum, and cerium silicate. It occurs in flat tabular crystals, also massive and in embedded grains. Cleavage in two directions. Brittle. Pitchy luster. Color brownish black. Hardness 5½ to 6. Specific gravity 3.5 to 4.2.

OCCURRENCE - Monazite in California is found mainly in sands or pegmatites, but may also occur as an accessory mineral in gneisses and granites. It has been reported from Butte, Del Norte, El Dorado, Humboldt, Placer, Plumas, Riverside, and Yuba counties but there has been no production.

Allanite is commonly associated with granitic rocks or pegmatites and is found in Calaveras, Riverside, San Diego, Tulare, and Tuolumne counties.

Florida beach sands contain monazite and a small amount was produced in 1940.

In Brazil and India, monazite is recovered as a by-product from the concentration of beach sands for their ilmenite, rutile and zircon content, and these countries furnish the chief supply.

PREPARATION - Cerium metal is prepared by electrolysis of the fused cerium chloride and is steel gray in color.

USES - Cerium oxide is used in glass, in the cores of searchlight, motion picture, and therapy lamp carbons. Cerium acetate has recently been used to prevent mildew.

Metallic cerium is used as a pyrophoric, ferrocerium, which causes the spark of most gas lighters.

Laboratory experiments have shown that a two percent addition of cerium to cast iron increases its fluidity and tensile strength, and acts as a desulfurizer.

Thoria, derived from monazite, is used in mantles for incandescent lights

MONAZITE AND ALLANITE
(continued)

TESTS - Monazite is infusible but turns gray. When moistened with sulfuric acid it turns the flame a pale bluish green. It is soluble in sulfuric acid. A test for phosphorus and a test for radio activity by an electroscope are confirmatory tests. Monazite resembles sphene and zircon and optical or micro-chemical tests may be required to distinguish it when in small amounts.

Allanite fuses easily and swells to a dark blebby, magnetic glass. Most varieties form a silica jell with hydrochloric acid, but if previously ignited they are not decomposed by acid. It is radioactive.

MARKETS - Per ton, minium eight percent thoria, $60.00.

POSSIBLE BUYERS:
Mercantile Import & Export Corp., 21 East 40th St., New York, N. Y.
Tennant, C. Sons & Co., of New York, 9 Rockerfeller Plaza, New York,N.Y.

REFERENCES:
Babst, Adolf., Minerals of California. California State Division of Mines Bulletin 113, 1938.
Bottschalk, V. H., The Uncommon Metals. E. & M. J. Volume 143, No. 2 Page 89. February 1942.
Minerals Yearbook, Review of 1940. U. S. Bureau of Mines, 1941.

NOTES:

1. Specimens of monazite, allanite, and other rare earth minerals may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. There are a number of other cerium bearing minerals of no commercial importance. Among them are samarskite $R_3R_2(Nb,Ta)_6O_{21}$ where R_2=Fe,Ca,UO_2 etc., and R_3= Cerium and yttrium metals chiefly. It was found associated with xenotime, monazite, tourmaline, orthoclase and garnet in the Southern Pacific silica quarry, one-half mile southeast of Nuevo, Riverside County.

Cerite, a hydrous cerium silicate was the first of the rare earth minerals to yield the new element didymium which was later broken down to the two elements praseodymium and neodymium.

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

JUNE - 1941

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

NICKEL

By
George L. Gary, Mineral Technologist

PROPERTIES - Pentlandite, (Fe,Ni)S is the principal ore mineral of nickel. It is usually found massive and in granular aggregates. Luster metallic. Brittle. Streak and color yellowish bronze. Hardness 3½-4. Gravity 4.6-5. The "nickeliferous pyrrhotite" ores of Sudbury, Ontario, Canada, are due to enclosed grains of pentlandite. Garnierite, $(Ni,Mg)SiO_3.nH_2O$ is also an important ore of nickel. It occurs as incrustations and earthy masses. Luster earthy to dull. Color apple-green to white. Hardness 2-3. Gravity 2.2 - 2.8.

OCCURRENCE - The principal nickel deposits have been formed by magmatic segregation or by superficial concentration from basic rocks. Nickel minerals occur also in vein deposits: In schists, gneiss and conglomerates near basic intrusive rocks and in the dikes themselves and as veins in serpentine containing hydrous nickel-magnesium silicates; due to a weathering of the peridotite to serpentine with a concentration of the nickel in the cracks and fissures as in the garnierite deposits of New Caledonia. Pentlandite has been found with pyrrhotite in Ventura and San Diego counties, California, and garnierite has been found in El Dorado, Imperial, Mariposa and San Benito counties.

PREPARATION - The Canadian sulfide ores are partially roasted to remove the excess sulfur, and smelted in blast furnaces to a matte carrying about 45 percent iron and about half that amount of copper plus nickel, which is then bessemerized, giving a matte of about the same composition as in New Caledonian practice, except that the metal content, instead of being only nickel, is copper and nickel, in the proportions present in the ore used. The bessemerized matte is subjected to a special smelting process which serves to separate the copper and nickel sulfides, after which the latter are roasted, smelted to a crude metal and electrolytically refined to a pure metal.

USES - Nickel is used in the manufacture of many alloys - german silver, monel metal, etc. A small percentage greatly increases the strength and hardness of steel, and the larger part of the nickel recovered is used for making nickel steel and nickel-chromium steel. A wide variety of nickel chemicals are produced for

NICKEL (continued)

laboratory purposes, as well as for minor industrial uses. Many of the military uses are identical with the ordinary industrial uses of the metal, the only difference being the emphasis which the emergency demand establishes, but, in addition to these, there are many strictly military uses, among which are armor plate for both naval and military use, many items of naval construction, gun forgings, recoil springs, and bullet jackets.

TESTS - Nickel compounds when dissolved in nitric acid give an apple-green solution and on the addition of ammonia a pale blue color results. If an alcoholic solution of dimethylglyoxime is added a scarlet precipitate is formed.

MARKETS - Nickel, per lb. electrolytic cathodes, 35¢. (Quotations June 5, 1941).

POSSIBLE BUYERS

Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, N.Y.
E. I. du Pont de Nemours & Co., Inc., (The R. & H. Chemicams Department), Wilmington, Del.
The Harshaw Chemical Co., Cleveland, Ohio.
The O. Hommel Co., 209 Fourth Avenue, Pittsburgh, Pa.
The McGean Chemical Co., 1106 Republic Building, Cleveland, Ohio
The Rufert Chemical Co., 420 Lexington Ave., New York, N. Y.
The Vitro Manufacturing Co., Corliss Station, Pittsburgh, Pa.

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G. A. Roush. Nickel. Strategic Mineral Supplies. McGraw-Hill Book Company, Inc., New York and London (1939). pp 70-96.
Staff of the Foreign Minerals Division, U. S. Bureau of Mines. Mineral Raw Materials. McGraw-Hill Book Company, Inc. New York and London (1937). pp 134-140.

NOTES

1. Specimens of nickel ores may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Niccolite, NiAs and millerite NiS are also ores of nickel. Small amounts of millerite have been found in Calaveras, Humboldt, Napa, Placer, Plumas and Ventura counties.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

MAY - 1942

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San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

NITRATES

By
George L. Gary, Mineral Technologist

PROPERTIES - Soda Niter, or caliche, sodium nitrate, $NaNO_3$, (Na_2O=36.5 percent, N_2O_5=63.5 percent) and niter or saltpeter, potassium nitrate, KNO_3, (K_2O = 46.5 percent, N_2O_5=53.5 percent) are the principal sources of nitrogen compounds.

The physical properties of these two minerals are as follows: Soda niter: Luster vitreous. Colorless or white, also reddish brown, gray, yellow. Transparent to translucent. Taste cooling. Deliquescent. Perfect rhombohedral cleavage. Hardness, 1 - 2. Specific gravity 2.24 - 2.29.
Niter: Luster vitreous. Color white. Translucent. Taste cooling. Non-deliquescent. Perfect domal cleavage. Hardness, 2. Specific gravity, 2.09 - 2.14.

OCCURRENCE - Sodium nitrates generally occur in nature mixed with sodium chloride and sodium sulfate, all combined with sand, gravel, clay and fragments of rock. Most of the numerous deposits in different parts of the world are comparatively small and low-grade, their content of sodium nitrate ranging from a mere trace to perhaps 5 percent; in fact, the only deposits of known commercial value are those of Chile.

Potassium nitrate occurs in caves and on rock ledges where the remains of excreta of mammals and birds are the chief source of the organic matter. Such deposits are necessarily limited in extent and are exploited by small-scale, primitive methods to supply the needs of the area in which they occur.

Nitrates can exist in solid forms only in arid regions, and are therefore peculiar to desert lands where they are sometimes left as white incrustations by evaporation. Some of these white crusts may be found in the California Desert land, but no important deposits are known according to Mansfield and Boardman (see reference section).

In Inyo County, California, crusts containing soda niter and niter occurring along the Amargosa River and along shore lines and old beaches of Death Valley, were reported by Bailey (see reference section). Crusts of soda niter and niter occur near Shoshone. The Confidence, Upper Canyon, Zabriskie, Ratliff Claims, and Furnace Creek nitrate fields contain small amounts of soda niter according to Noble (see reference section).

In Merced County, California, soda niter occurs in crusts with other sodium salts, from Merced Bottom.

In San Bernardino County, California, white incrustations containing soda niter and niter occur along the Amargosa River. Small

amounts of soda niter have been found in the Calico district according to Williams (see reference section). Small amounts of soda niter have been found at Searles Lake. The Lower Canyon, Saratoga, Upper Canyon, Barstow syncline, Coalgardie Lake, Pilot, Leach Lake, Owl Springs, Twenty-nine Palms, West Well, Beal, Vivet Eye, Vidal, and Danby Lake nitrate fields contain small amounts of soda niter and niter according to Noble (see reference section).

In Tulare County, California, alkaline crusts containing soda niter with soda salts occur in the San Joaquin Valley, near Tulare.

In Imperial County, California, niter occurs along the former high levels of the Salton Sea according to Bailey (see reference section).

In Modoc County, California, incrustations of niter have been found near Cedarville.

In Riverside County, California, Bailey (see reference section) mentions saltpeter as occurring in the desert northeast of Salton.

PREPARATION - The salts are dug from shallow pits, and the sorted material is taken by rail to the reduction works, where the salts are crushed, leached by boiling water, crystallized and refined. Iodine is won as a by-product of this operation from the sodium iodates which accompany these salts.

USES - The principal uses of nitrates are as fertilizers and in the manufacture of chemicals and explosives. With the development of synthetic processes for the production of nitrates the importance of natural nitrates and the quantities used began to decline. At present, less than 10 percent of the world's industrial and fertilizer nitrogen comes from natural nitrate. Approximately 60 percent is derived by the extraction of nitrogen from the air by synthetic methods; the balance is obtained as a by-product, principally by the coking of coals. Of the world consumption of nitrogen compounds, approximately 85 percent goes into the fertilizer industry. During war times the manufacture of nitric acid for military use is second in importance as a consumer of industrial nitrogen compounds, but during peace times the manufacture of sulfuric acid, the manufacture of nitrogen chemicals, and commercial explosives, are far more important as nitrogen consumers than are military requirements.

TESTS - Nitrates detonate when heated on charcoal. Heated in a tube with sulfuric acid they give off red fumes of nitrogen dioxide (NO_2). Pour 1 cc of the $NaNO_3$ solution in a test tube and add about 5 cc of strong H_2SO_4. Hold the test tube in a slanting position, and carefully pour down the lower side 3-5 cc of a saturated solution of $FeSO_4$, flowing over the H_2SO_4 but without mixing with the acid. Tap the tube gently and note the brown ring that forms at the junction of the acid and $FeSO_4$.

MARKETS - Soda nitrate, crude, domestic, c.l., 100 lb. bags, delivered f.o.b. cars, producing points or ports, rail or boat shipments, ton $30.05. Imp., c.l., 100 lb. bags, f.o.b. cars, Atlantic, Gulf, Pacific Warehouses, rail or boat shipments, ton $33.00 - 200 lb. bags, same basis, ton $32.00 - bulk, same basis, ton $30.00

MARKETS (cont'd.)

Saltpeter, double refined, gran. bbls.
10-20 tons - 100 lbs. $8.20
1-9 tons - 100 lbs. $8.35
Less than ton lots - 100 lbs. $8.60
(Quotations April, 1942).

POSSIBLE BUYERS

Sodium Nitrate:
J.T.Baker Chemical Co., Phillipsburg, N. J.
The Barret Co., 40 Rector St., New York, N. Y.
Chilean Nitrate Sales Corporation, 120 Broadway, New York, N. Y.
Croton Chemical Corp., 57 Commerce St., Brooklyn, N. Y.
E. I. DuPont De Nemours & Co., Inc., (The R. & H. Chemicals Dept.) Wilmington, Del.
Prior Chemical Corporation, 420 Lexington Avenue, New York, N. Y.
Stauffer Chemical Co., 624 California St., San Francisco, Calif.

Saltpeter
J. T. Baker Chemical Co., Phillipsburg, N. J.
Chilean Nitrate Sales Corporation, 120 Broadway, New York, N. Y.
Croton Chemical Corporation, 57 Commerce Street, Brooklyn, N. Y.
E. I. DuPont De Nemours & Co.,Inc., (The R. & H. Chemicals Div.) Wilmington, Del.
General Chemical Co., 40 Rector St., New York, N. Y.
Innis, Speiden & Co., Inc., 117 Liberty St., New York, N. Y.
Jungmann & Co., Inc., 157 Chambers St., New York, N. Y.
Mercantile Import & Export Corp., 21 East 40th St., New York, N. Y.
Wilson & George Meyer & Co., 601 Federal Reserve Bank Building, San Francisco, California.
Pryor Chemical Corporation, 420 Lexington Ave., New York, N. Y.
H. H. Rosenthal Co., Inc., 25 East 26th Street, New York, N. Y.
Stauffer Chemical Co., 624 California Street, San Francisco, Calif.
Wishnick-Tumpeer, Inc., 295 Madison Avenue, New York, N. Y.

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Mansfield, G.R. and Boardman, L. Nitrate Deposits of the United States. Bulletin 838 - U. S. Geological Survey, 1932.
Noble, Levi F. Nitrate deposits in southeastern California with notes on deposits in southeastern Arizona and southwestern New Mexico. Bulletin 820 - U. S. Geological Survey, 1931.
Pabst, Adolf. Minerals of California. Bulletin 113, California State Division of Mines. 1938.
Williams, Albert, Jr., Nitrate of Soda. Mineral Resources, 599-600. U. S. Geological Survey. 1883.

NOTES:
1. Specimens of nitrates may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco.
2. Other nitrates of less importance found in California are:
Nitrocalcite, a hydrous calcium nitrate, $Ca(NO_3)_2.nH_2O$. which occurs in the niter beds of the lower end of Death Valley, San Bernardino County, according to Bailey (see reference section).
Daraskite, a hydrous nitrate and sulfate, $NaNO_3.Na_2SO_4.H_2O$. which occurs in the niter beds of Death Valley, San Bernardino County, according to Bailey (see reference section).

State of California
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DIVISION OF MINES

Walter W. Bradley
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PHOSPHATES AND PHOSPHATE ROCK

By
George L. Gary, Mineral Technologist

PROPERTIES - As defined by Johnson (I.C. 6256) "phosphate rock is a general name applied to certain rocks of different degrees of consolidation and of divers origins, characters, and modes of occurrence, composed of intimate mixtures of various allied amorphous or rarely crystallized phosphate minerals, usually calcium phosphates with various impurities. Included in this term are phosphatized limestone, sandstone, shale, and igneous rocks; amorphous nodular phosphates; residual weathered phosphatic limestones; vein phosphates; and phosphate sediments, both unconsolidated and consolidated."

Collophane is the chief constituent of phosphate rock. It is a hydrous calcium phosphate with varying amounts of calcium carbonate, calcium fluorite, and calcium sulfate of the formula $3Ca_3(PO_4)_2 \cdot nCa(CO_3, F_2, O)(H_2O)$. It is amorphous and usually occurs massive, often concretionary or oolitic and sometimes banded. The color may be white, gray, yellow, brown or black and is due to organic matter. Hardness 3 to 5. Specific gravity 2.6 to 2.9.

Apatite, $Ca_5(Cl,F)(PO_4)_3$, calcium chloro-fluo phosphate, occurs in hexagonal prismatic and tabular crystals to massive, granular, or compact. Luster subresinous. The color is usually reddish brown or green but it may be white, colorless, gray, blue, or violet. Hardness 5. Specific gravity 3.2.

OCCURRENCE - No commercial deposits of phosphate rock (collophane) or apatite have been found in California although apatite occurs in Amador, Calaveras, Contra Costa, Fresno, Placer, Plumas, Riverside, San Bernardino, and San Diego counties; and collophane has been reported from Fresno, Humboldt, Los Angeles, and Monterey counties.

The domestic supply of phosphates comes from Florida, South Carolina, Tennessee, Kentucky, Arkansas, Idaho, Wyoming, Utah and Montana.

The Florida land-pebble deposits are reconcentrations from marine phosphate-bearing limestone.

The brown phosphate rocks of Tennessee and Kentucky are residual products left after the calcium carbonate of the original limestone had been leached out.

The phosphate rock deposits of the Western United States are of marine origin formed by the deposition of calcium phosphate from phosphatic solutions or colloids on the sea bottom.

There are no large deposits of apatite in the United States.

PREPARATION - Beneficiation of the poorer grade material usually consists of sizing, disintegration and washing, screening, classifying and drying. Some phosphates are amenable to table concentration and flotation.

The better grade phosphates which come from Tennessee and the Western States require only crushing and drying.

Some phosphates are calcined to remove organic matter when the material is to be used for making phosphoric acid.

USES - Most of the phosphate rock produced is used in making fertilizer, usually in the form of superphosphate (Superphosphate as defined by the Association of Official Agricultural Chemists is "a product obtained by mixing rock phosphate with sulfuric acid or phosphoric acid, or with both acids. The grade that shows the available phosphoric acid shall be used as a prefix to the name, for example, 20 percent superphosphate").

Smaller amounts of phosphate rock are used to produce phosphorous, phosphoric acid, dicalcium phosphate, trisodium phosphate, and other chemicals.

Some phosphate rock is finely ground and applied directly to the soil as a fertilizer.

TESTS - The most satisfactory test for a phosphate is to dissolve some of the finely powdered material in nitric acid and add a portion of this solution to a solution of ammonium molybdate. If a phosphate is present, a pulverulent yellow precipitate of ammonium phosphymolybdate will form. The solution should be cold, as arsenates give a similar precipitate in a boiling solution.

A green or greenish blue color is imparted to the flame by phosphates, especially after having been moistened with sulfuric acid, but this test is unsatisfactory because impurities usually obscure the color. Also, since the blow-pipe flame is blue, a greenish blue color is difficult to distinguish.

MARKETS - Phosphate rock is generally sold on a basis of the tricalcium or bone phosphorous of lime (B.P.L.) content. Commercial grades generally run from 68 to 77 percent B.P.L.

Per long ton, f.o.b. mines Florida pebble, domestic: 77 @ 76 percent, $3.65; 75 @ 74 percent, $2,90; 72 percent, $2.40; 70 percent, $2.15. Quotations April 1942.

POSSIBLE BUYERS:

The American Agricultural Chemical Co., 50 Church St.,New York, N.Y.
American Cyanamid & Chemical Corp., 30 Rockerfeller Plaza, New York,N.Y
Anaconda Sales Co., Anaconda, Montana.
Armour Fertilizer Works, Walton Building, Atlanta, Ga.
Coronet Phosphate Co., 19 Rector St., New York, N. Y.
L.W. Huber Co., 170 Broadway, New York, N. Y.
International Agricultural Corp., 61 Broadway, New York, N. Y.
Alexander M. McIver & Son, 503 Peoples Building, Charleston, S. C.
The Phosphate Mining Co., 110 William St., New York, N.Y.
H. D. Ruhm, 305 West Seventh Street, Columbia, Tenn.
Virginia-Carolina Chemical Corp., P.O.Box 667, Richmond, Va.

PHOSPHATES AND PHOSPHATE ROCK
(continued)

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Jacob et al. Nutrient Value of the Phosphorous in Calcined Phosphate. Journal of Agriculture Research No.10, May 1935.

Ross, W. H. Use and Preparation of Concentrated Fertilizers. Transactions American Electrochemical Society. Vol.48, pp 293-305, 1925.

NOTES:

1. Specimens of apatite and phosphate rock may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco.

2. Other sources of phosphates are guano, marl, and bones.

3. The deposit of wavellite (a basic hydrous aluminum phosphate) at Mt. Holly Springs, Pennsylvania, has been used as a source of phosphate.

4. Voelckerite, a variety of apatite containing little or no fluorine or chlorine is characteristic of the glaucophane schist in the Coast Ranges. The formula is $3Ca_3(PO_4)_2CaO$.

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[illegible] Chemical Education Quarterly Journal, Vol. [illegible],
pp. [illegible], 1970.

NOTES:

1). Investigate the specific gravity procedure used by each lab
[illegible] after determining their Dilution of Ohio, Perry Building.
[illegible] Procedure.

2). Check results of [illegible] Phase, [illegible] and Ammo.

3). The experiment was [illegible] to the previous chemistry phase-
[illegible] of the Early Periods, [illegible], but Color Dyes of a Mixture
[illegible] Chromatography.

4). Investigate [illegible] of Copper Sulfate [illegible] Little or no
[illegible] of Copper Sulfate [illegible] the Electrolyte Added in
[illegible] Cuprous Chloride. The Formula is $CuCl_2(OH)_2$.

State of California
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DIVISION OF MINES

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COMMERCIAL MINERALS OF CALIFORNIA
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PLATINUM

By
George L. Gary, Mineral Technologist

PROPERTIES - The "platinum group metals" include platinum (Pt), iridium (Ir), osmium (Os), palladium (Pd), rhodium (Rh), and ruthenium (Ru). They are all grayish-white, lustrous metals, highly resistant to erosion, and they all melt only at a high temperature. The specific gravity of platinum, iridium, and osmium varies from 21.50 to 22.47 when pure and the specific gravity of palladium, rhodium, and ruthenium varies from 12.10 to 12.44 when pure. The hardness of platinum varies from 4 - 4½; iridium, 6½; osmium, 7; palladium, 4½ - 5; rhodium, ---; and ruthenium, 6½. Most of the platinum of California is alloyed with other metals of the platinum group and much of it would be classed as platiniridium. Iridosmine, a native alloy of iridium and osmium is a frequent associate of platinum; it sometimes shows the presence of the rarer metals, rhodium and ruthenium.

OCCURRENCE - In California platinum sands occur in small amounts in the principal placer mines of the gold belt of the Sierra Nevada, but in no place is the metal so abundant that the deposit can be worked for platinum alone. This metal undoubtedly came originally from the serpentine and peridotite or pyroxenite, which occur as intrusive masses throughout the gold belt. In many places iridosmine in small silvery-white scales is more common than platinum itself. Little or no platinum was recovered until the beginning of dredging operations on a large scale along the foothills of the mountains. The gold is recovered by amalgamation, but the platinum is in the black sand and is saved by panning. The platinum occurs in very small scales and grains, as a rule somewhat smaller than the gold, which in the dredging fields generally passes a 100-mesh screen; the quantity is very small. A few ounces of platinum are recovered also from some of the placer mines in northwestern California in Siskiyou, Trinity, Humboldt, and Del Norte counties. Serpentine and peridotite are abundant in this region, and the platinum is undoubtedly derived from these rocks. The presence of platinum is characteristic of the beach sands along the Pacific Coast. The principal beaches where platinum has been reported from California are Santa Barbara, Lompoc, Santa Cruz, and occasional points between Santa Cruz and the Golden Gate. The richest beaches are further north in Humboldt and Del Norte counties. Though platinum occurs widely in California, it has not been positively identified as a

PLATINUM (Continued)

constituent of any rocks. As noted in Bulletin 113 of the California State Division of Mines platinum has been found in the following counties: Butte, Calaveras, Del Norte, El Dorado, Humboldt, Inyo, Kern, Mariposa, Mendocino, Merced, Nevada, Placer, Plumas, San Bernardino, San Luis Obispo, Santa Barbara, Santa Cruz, Shasta, Siskiyou, Tehama, Trinity, Ventura and Yuba.

PREPARATION - Crude platinum can be refined either by wet or dry methods or by a combination of the two. The standard wet method involves dissolving the platinum in aqua regia, precipitating as ammonium platinic chloride, heating to redness, and thus fusing the spongy platinum with an oxyhydrogen blowpipe in a furnace made from blocks of lime or in an electric furnace. After thus removing the platinum the other metals of the platinum group are recovered from the solution and from the insoluble residue. In theory the separation of the various platinum metals from other metals and from each other is quite simple, but the manipulation is said to be different and is complicated further by the precautions necessary to prevent loss of the expensive materials. As to details reference may be made to a paper by Wichers, Gilchrist and Swanger, which is listed in the bibliography of this paper covering work done on platinum metals at the U. S. Bureau of Standards.

USES - The industrial uses of platinum depend chiefly upon its high fusing point (1755° C.) and its resistance to chemical attack. It is valuable for crucibles, dishes, spoons, and all sorts of laboratory apparatus; when used for such purposes a small amount of iridium is usually added to increase its hardness and durability. In the contact process for the manufacture of sulfuric acid, platinum is the best catalyst, but it has been partly replaced by cheaper but less efficient material, such as vanadium oxide, V_2O_5. Platinum is used in the platinum resistance thermometer and the rhodium-platinum thermocouple, devices for measuring high temperatures. It is also used in electrical apparatus for contact-points of bells, magnetos and induction coils. Considerable platinum is used in jewelry and in dentistry, but because of the increased price of the metal, gold and gold alloys are gradually taking its place. Platinum is used in making photographic prints and is superior to silver in that it gives a greater variety of tone and is permanent.

TESTS - The material to be examined is dissolved in aqua regia and evaporated to dryness, redissolved in hydrochloric acid and boiled down to a thin paste (not quite dry); add distilled water and a few drops of sulfuric acid. To this solution a little potassium iodide is added which, if platinum is present, produces a characteristic wine-red coloration ranging to a reddish pink in the presence of only small quantities.

PLATINUM (Continued)

MARKETS

Platinum - per oz. troy, official price of leading interest, $36.
Iridium - per oz. troy, $175, for sponge or powder.
Osmium - per oz. troy, $45 @ $48.
Palladium - per oz. troy, $24.
Rhodium - per oz. troy, $125, nominal.
Ruthenium - per oz. troy, $35 @ $40.
(Quotations June 1941)

POSSIBLE BUYERS

American Platinum Works, N. J. R. R. Ave., at Oliver St., Newark, N.J.
Baker & Co., Inc., 54 Austin St., Newark, N. J.
J. Bishop & Co., Malvern, Pa.
Goldsmith Bros., Smelting and Refining Co., 58 E. Washington St., Chicago, Ill.
S. B. Gracier & Sons, 212 Stockton St., San Francisco, Calif.
Handy & Harman, 57 William St., New York, N. Y.
Irvington Smelting and Refining Works, Irvington, N. J.
Pacific Platinum Works, 814 S. Spring St., Los Angeles, Calif.
Platinum Metals Corp., 261 Fifth Ave., New York, N. Y.
Geo. R. Randolph, 833 Market St., San Francisco, Calif.
Shreve & Co., Bryant and Zoe Sts., San Francisco, Calif.
Western Gold and Platinum Works, 589 Bryant St., San Francisco, Calif.
S. S. White Dental Co., Philadelphia, Pa.
Wildberg Bros. Smelting and Refining Co., 742 Market St., San Francisco, Calif.

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Edward Wichers, Raleigh Gilchrist, and Wm. N. Swanger. Purification of the Six Platinum Metals. Trans. Am. Inst. Min. and Met. Eng., vol. 76, (1928), pp. 602-630.

NOTES

1. Specimens of platinum minerals may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. The only known natural compound of platinum is the arsenide, sperrylite, $PtAs_2$, which has been found sparingly in two or three localities in association with copper and nickel ores.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

MAY - 1942

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COMMERCIAL MINERALS OF CALIFORNIA
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PYRITE AND SULFUR

By
George L. Gary, Mineral Technologist

PROPERTIES - Sulfur (S) occurs in crystals, incrustations, disseminations, and compact masses. There is no cleavage but it is very brittle. Luster resinous to glassy. Color, yellow when pure but it may be orange, brown, gray or black. Hardness 1½ to 2½. Specific gravity 2.05 to 2.09.

Pyrite (FeS_2) iron disulfide. Cobalt and nickel sometimes replace part of the iron. Finely divided gold is frequently intimately associated with pyrite, and copper and arsenic are sometimes present. The cube and pyritohedron are the most common crystal forms and the faces are frequently striated. The mineral usually occurs massive, or fine granular but it may be subfibrous radiated; also reniform, globular and stalactitic. Luster metallic. Streak greenish black or brownish black. Color pale brass-yellow. Hardness 6 to 6½. Specific gravity 4.95 to 5.10.

OCCURRENCE - Commercial deposits of sulfur in the United States occur usually in sedimentary beds with gypsum and limestone and were probably formed by the action of the organic matter on gypsum. Sulfur is also formed from hydrogen sulfide gas (H_2S) in and near volcanoes, and superficial sulfur deposits of the same origin are common near hot springs. Sulfur produced by the alteration of sulfide minerals has never been found in commercial quantities.

In California sulfur is found in 14 counties, the most important of which are Alpine and Inyo counties. Sulfur from the Leviathan Mine, Alpine County occurs disseminated through brecciated tuff and as large yellow masses.

The Inyo County deposits are located in the Last Chance Range and occur in sedimentary beds with gypsum and limestone.

The enormous deposits of Louisiana and Texas are the most important domestic source of sulfur and were derived from gypsum.

Italy, Sicily, Japan, Spain, and Chili are also important producers of sulfur.

Pyrite is the most common of the sulfide minerals, occurring all kinds of rock, but it is especially prominent in metamorphic schists, slates, quartzites, quartz veins, and unalteres sandstones.

The only present-operated commercial deposits of pyrite in California is in Shasta County where it occurs in a shear zone in rhyolite. In former years, production came also from Alameda County

The main production of pyrite in the United States is from Tennessee.

Spain has long been the world's chief source of pyrite. Norway and Finland contribute pyrite as a by-product of copper mining.

PREPARATION - There are several ways of extracting sulfur from its containing rock. Sulfur from the Texas deposit is recovered by the Frash process. This method employs super-heated water (300°F) which is forced down a cased well (composed of concentric pipes) to the sulfur bed where it escapes into the formation through perforations in the casing. The heat of the water melts the sulfur which then settles to the underlying formation (anhydrite, $CaSO_4$ in this case) and enters the well casing through perforations in the bottom of the casing, this section being sealed off from the hot-water passage. Compressed air forced down the center pipe assista in bringing the sulfur to the surface where it runs into large vats and is allowed to solidify. The product is very pure and usually requires no further treatment.

Other extraction methods applicable to sulfur mines by conventional methods involve melting the sulfur by super-heated steam or by burning a part of the sulfur in Gill regenerative kilns.

Pyrite when roasted yields sulfur dioxide which is used to make sulfuric acid. The residue of ferrous oxide (FeO) may be used as a source of iron.

USES - Both native sulfur and pyrite are used to make sulfuric acid. Sulfur is used in the sulfide and sulfate processes for making paper from wood pulp. It is also important as a fungicide and insecticide.

Sulfur dioxide is valuable in the chemical industries and is the major refrigerant in small refrigerating systems. It is used as a bleach and as a food preservative.

Sulfur is incorporated in rubber in the correct p oportions before vulcanizing to yield a product of varying degrees of hardness. Without the addition of sulfur, rubber products would be useless.

The use of sulfur in explosives is now confined to black powder, although in the form of sulfuric acid, sulfur is used in the manufacture of nitroglycerin.

TESTS - Native sulfur may be recognized by its color, light weight, and by the fact that it burns readily, giving off an irritating odor (sulfur dioxide). Pure sulfur when placed on a silver coin and moistened with water, will leave a black or yellow stain of silver sulfide.

Pyrite is distinguished from pyrrhotite and chalcopyrite by its pale brass-yellow color and inferior hardness. It is soluble in nitric acid.

MARKETS - Sulfur, per long ton f.o.b. Texas mines for domestic market, $16.00.

POSSIBLE BUYERS:

PYRITE
Leonard J. Buck, Inc., 1 Newark Avenue, Jersey City, N. J.
The Davidson Chemical Corporation, 20 Hopkins Place, Baltimore, Md.
General Chemical Co., 400 Sansome St.,San Francisco, California
Stauffer Chemical Co., 636 California St,, San Francisco, California
St. Jos ph Lead Co., 250 Park Avenue, New York, N. Y.

PYRITE AND SULFUR
(continued)

POSSIBLE BUYERS

PYRITE (cont'd.)

Henry Suhl, Inc., 149 Broadway, New York, N. Y.
Sulphur Mining & Railroad Co., 627 East Main St., Richmond, Va.
C. Tennant, Sons & Co., New York, 9 Rockerfeller Plaza, New York, N.Y.

SULFUR

American Cyanide & Chemical Corp., 30 Rockerfeller Plaza, New York, N.Y.
Douglas Sulphur Co., P. O. Box 231, Houston, Texas.
Freeport Sulfur Co., 122 East 42nd St., New York, N. Y.
General Chemical Co., 400 Sansome St, San Francisco, California
Koppers Company. Tar & Chemical Division. 1201 Koppers Bldg.
Pittsburgh, Pa.
Los Angeles Chemical Company, 1960 Santa Fe Avenue, Los Angeles, Calif.
McKesson & Robbins, Inc., Heavy Chemical Div., 155 East 44th Street,
New York, N. Y.
Monsanto Chemical Company, 1700 South Second Street, St. Louis, Mo.
Niagara Sprayer & Chemical Co., Inc., Middleport, N. Y.
Republic Chemical Corporation, 94 Beekman St., New York, N. Y.
Stauffer Chemical Company, 636 California Street, San Francisco, Calif.
Texas Gulf Sulphur Co., Inc., 75 East 45th Street, New York, N. Y.
The Vitro Manufacturing Co., Corliss Station, Pittsburgh, Pa.
Vishnick-Tumpeer, Inc., 295 Madison Avenue, New York, N. Y.

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Tabst, Adolf. Minerals of California. Bulletin 113, California
State Division of Mines, 1938.

Ridgway, Robert H. Sulfur - General Information. Information
Circular 6329, U. S. Bureau of Mines, 1930.

NOTES

1. Samples of pyrite and sulfur may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Marcasite, also FeS2, may be distinguished from pyrite by its orthorhombic crystals. The twin "fiveling" which presents a sawtooth profile, is very characteristic. When dissolved in nitric acid marcasite yields free sulfur, whereas the sulfur of pyrite is converted to sulfuric acid.

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

June - 1941

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

QUARTZ

By
George L. Gary, Mineral Technologist

PROPERTIES - Quartz, silica, or silicon dioxide, SiO_2, occurs in many different forms; as crystals commonly prismatic, with prism faces horizontally striated, also in massive forms of great variety. From coarse to fine-grained crystalline to flint like or cryptocrystalline, giving rise to many variety names. It also may form in concretionary masses; as sand. Fracture conchoidal or shell-like. Luster vitreous, in some specimens greasy, splendent. Transparent to translucent. Possesses strong piezoelectric and pyroelectric properties. Streak and color usually colorless or white, but frequently colored by various impurities and may then be any color. The hardness is 7; the gravity 2.65.

The more important varieties with a brief description of each, follow:

Coarsely Crystalline Varieties

1. Rock Crystal. Colorless quartz, commonly in distinct crystals.
2. Amethyst. Quartz colored purple or violet, often in crystals.
3. Rose Quartz. Coarsely crystalline, but without crystal form, color a rose-red or pink. Often fades somewhat on exposure to light.
4. Smoky Quartz; Cairngorm Stone. Frequently in crystals of a smoky yellow to brown and almost black color. Named cairngorm from the locality of Cairngorm in Scotland.
5. Citrine. Light yellow in color.
6. Milky Quartz. Milky white in color owing to minute liquid inclusions. In some cases with greasy luster.
7. Cat's-eye. A stone which, when cut in a round shape (en cabochon), exhibits an opalescent or chatoyant effect, as it is termed, is called a cat's-eye. Quartz among other minerals, gives at times this effect, which is due either to fibrous inclusions or to the fibrous nature of the quartz itself. The latter is seen in tiger's-eye, a yellow fibrous quartz from South Africa, which is pseudomorphic after the fibrous mineral crocidolite.
8. With Inclusions. Many other minerals occur as inclusions in quartz and thus give rise to variety names. Rutilated quartz has fine needles of rutile penetrating it. Tourmaline and other minerals are found in quartz in the same way. Aventurine is quartz including brilliant scales of hematite or mica. Liquids and gases may occur as inclusions; both liquid and gaseous carbon-dioxide exist in some quartz.

QUARTZ (continued)

Cryptocrystalline Varieties

The cryptocrystalline varieties of quartz may be divided into two general classes; namely, fibrous and granular, which in most cases, are impossible to tell apart without microscopic aid.

A. Fibrous Varieties

Chalcedony is the general name applied to those varieties having a fibrous alignment of particles, visible however only under the microscope. It is more specifically thought of as a brown translucent variety, with a waxy luster, often mammillary and in other imitative shapes. Chalcedony has been deposited from aqueous solutions and is frequently found lining or filling cavities in rocks. Color and banding give rise to the following varieties:

1. Carnelian. A red chalcedony.
2. Chrysoprase. An apple-green chalcedony.
3. Heliotrope or bloodstone. A green chalcedony with small red spots in it.
4. Agate. A variegated variety with alternating layers of chalcedony and opal, or granular cryptocrystalline quartz. The different colors are usually in delicate, fine parallel bands which are commonly curved, in some specimens concentric. Most agate used for commercial purposes is colored by artificial means. Some agates have the different colors not arranged in bands but irregularly distributed. Moss agate is a variety in which the variation in color is due to visible impurities, often manganese oxide in moss-like patterns. Wood that has been petrified by replacement by clouded agate is known as silicified or agatized wood.
5. Onyx. Like agate, is a layered chalcedony and opal, with layers arranged in parallel planes.

B. Granular Varieties

1. Flint. Something like chalcedony in appearance, but dull, often dark in color. It usually occurs in nodules in chalk and breaks with a prominent conchoidal fracture giving sharp edges. Used for various implements by early man.
2. Chert. A compact massive rock similar in most properties to flint, but usually light in color.
3. Jasper. A granular cryptocrystalline quartz, usually colored red from hematite inclusions.
4. Prase. Dull green in color; otherwise similar to jasper, and occurs with it.

OCCURRENCE - Quartz occurs as an important constituent of those igneous rocks which have an excess of silica, such as granite, rhyolite, pegmatite. It is extremely resistant to both mechanical and chemical attack, and thus the breakdown of igneous rocks containing it yields quartz grains which may accumulate and form the sedimentary rock sandstone. Also occurs in metamorphic rocks, as gneisses and schists, while it forms practically the only mineral of quartzites. Deposited often from solution and is the most common vein and gangue mineral. Forms as flint deposited with chalk on the sea floor in nodular masses. Solutions carrying silica may replace beds of limestone with a granular cryptocrystalline quartz known as chert, or discontinuous beds of chert may form contemporaneously with the limestone. In rocks it is associated chiefly with feldspar and

QUARTZ (Continued)

muscovite; in veins with practically the entire range of vein minerals. Often carries gold and becomes an important ore of that metal. Occurs in large amount as sand in stream beds and upon the seashore and as a constituent of soils. Many forms of silica are produced in commercial amounts in California as sand, quartz, quartzite, sandstone and chalcedony. Fine large specimens of rock crystals, smoky quartz, rose quartz and a small amount of amethyst have been found in California as well as other varieties of quartz mentioned herein.

PREPARATION - Methods of mining the various siliceous materials vary widely, dependent on the form of the material, nature and location of deposits, and type of product to be made. However, most of the deposits are worked by open-pit or quarrying methods, often in a very crude way. Sand deposits may be worked by hydraulicking, by dredging or by the use of a steam shovel. Vein quartz is often obtained as a by-product in the mining of other materials. Pegmatite quartz is almost always obtained as a by-product in working pegmatite dikes for feldspar or mica. In the grinding and preparation of silica for market several methods are in use, dependent upon the type of raw material, the character of the product desired, and the progressiveness of the producer. For ceramic use silica is ordinarily ground to pass through a 140 mesh sieve, but for paint, polishes, fillers, etc., much finer grinding is necessary, a 200 or even 300 mesh product being required. For sand paper much coarser grains are needed and these grains must be carefully graded by size. Massive flint and crystalline quartz are very hard and tough. Crushing the crude rock is difficult and expensive, and to obviate this it is often calcined before crushing. Calcination is usually done in a small vertical kiln, resembling a lime kiln, fired with wood or coal, in which is placed alternate layers of rock and fuel. As the fuel burns away the charge slowly sinks in the kiln, the heated rock being removed at the bottom and quenched with water. The calcined rock may then be broken down by hand, and fed to "chaser mills" or crushed in jaw crushers, possibly followed by chaser mills. Fine grinding may be done either wet or dry. Wet grinding may be accomplished in conical mills, short tube mills, in long tube mills or in wet grinding pans. If a wet grinding process is used the finished product is usually sized by some system of water classification. Dry grinding may be done in conical mills, short pebble mills of the intermittent type or long tube mills. In dry grinding methods sizing of the finished product is not common, but in some instances air separation may be used. The wet ground product may be dried by steam in open tanks or over steam-pipe racks or in rotary driers.

USES - Quartz is widely used in its various colored forms as ornamental material. As sand used in mortar, in cement, as a flux, as an abrasive, and in the manufacture of glass and silica brick. In powdered form is used in porcelain, paints, sandpaper, and scouring

(Continued)

QUARTZ (Continued)

soaps, and as a wood filler. As quartzite, sandstone, and in its various other rock forms as a building stone and for paving purposes. Large amounts of quartz sand are used as an acid flux in certain smelting operations. As rock crystal in various optical and electrical equipment. Its military use is in radio transmitting and receiving sets for controlling the output frequency of the radio transmitters and the response frequency of the radio receivers and in frequency meters.

TESTS - Infusible even on the thinnestedges. When fused with an equal volume of sodium carbonate, effervesces and gives a colorless glass; unacted upon by salt of phosphorus. Soluble only in hydrofluoric acid.

MARKETS - Quartz Rock Crystals - For fusing, all sizes, $100 @ $150 per ton. Prisms for piezo-electrical and optical use command premium. Silica - Per ton, water ground and floated, in bags, f.o.b. Illinois: 325 mesh, $21 @ $40 for 92 to 99½ percent grades. Dry-ground, air-floated, 325 mesh, 92 @ 99½ percent silica, $18 @ $30. Glass sand, f.o.b. producing plant, $1.25 @ $5 per ton; molding sand, 50¢ @ $3.50; blast sand, $1.75 @ $6. California: $5 for quartz and $2.50 for sand. (Quotations May 1, 1941.)

POSSIBLE BUYERS

Silica

Charles B. Chrystal Co., Inc., 11 Park Pl., New York, N. Y.
The Dicalite Company, 120 Wall St., New York, N. Y.
Stanley Doggett, Inc., 75 Varick St., New York, N. Y.
Industrial Minerals & Chemical Co., 6th & Gilman Sts., Berkeley, Calif.
Innis Speiden & Co., Inc., 117 Liberty St., New York, N. Y.
Johns-Manville Corp., 22 East 40th St., New York, N. Y.
Kennedy Minerals Co., 2550 East Olympic Blvd., Los Angeles, Calif.
L. A. Salomon Bro., 216 Pearl St., New York, N. Y.
Smith Chemical & Color Co., 55 John St., Brooklyn, N. Y.
Tamms Silica Co., 228 North La Salle St., Chicago, Ill.
United Clay Mines Corp., Prospect and Oakland St., Trenton, N. J.
Western Talc Co., 1901 East Slauson Ave., Los Angeles, Calif.
Whittaker, Clark & Daniels, Inc., 260 West Broadway, New York, N. Y.
C. K. Williams & Co., 640 North 13th St., Easton, Pa.
Wishnick-Tumpeer, Inc., 295 Madison Ave., New York, N. Y.

Quartz Crystals

Bausch & Lomb, Rochester, N. Y.
General Electric Co., Schenectady, N. Y.
U. S. Navy Department, Federal Office Bldg., Civic Center, San Francisco, Calif.

QUARTZ (Continued)

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Herbert Hughes. Granules. Industrial Minerals and Rocks. The American Institute of Mining and Metallurgical Engineers. New York (1937) pp. 347-352.

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H. Ries. Special Sands. Industrial Minerals and Rocks. The American Institute of Mining and Metallurgical Engineers. New York (1937) pp. 749-762.

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J. R. Thoenen. Sand & Gravel. Industrial Minerals and Rocks. The American Institute of Mining and Metallurgical Engineers. pp. 671-720.

Paul M. Tyler. Quartz. Industrial Minerals and Rocks. The American Institute of Mining and Metallurgical Engineers. New York (1937) p. 517.

NOTES

1. Specimens of quartz may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Silica sand suitable for glass manufacturing would no doubt be of interest to the following glass companies:

Brock Glass Co., 202 Santa Fe St., Santa Ana, Calif.
Chrysolite Products Corp., 1708 Standard Ave., Glendale, Calif.
A. H. Fostar Co., 2414 E. 58th St., Los Angeles, Calif.
Technical Glass Co., 2050 E. 48th St., Los Angeles, Calif.
Hazel-Atlas Glass Co., 89th & G. St., Oakland, Calif.
Lathford Marble Glass Co., 7441 Roseberry Ave., Huntington Park, Calif.
Glass Products, Inc., 2435 E. 56th St., Los Angeles, Calif.
Glass Containers Corp., 36th & Santa Fe., Los Angeles, Calif.
Maywood Glass Co., 5615 S. Riverside Drive, Los Angeles, Calif.
Mississippi Glass Co., Fullerton, Calif.
Owens-Illinois Pacific Coast Co., 1855 Folsom St., San Francisco, Calif.
Philadelphia Quartz Co., Quartz & Independent St., South Gate, Calif.
Los Angeles Chemical Co., 1960 Santa Fe., Los Angeles, Calif.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

MAY - 1941

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

QUICKSILVER

By
George L. Gary, Mineral Technologist

PROPERTIES - The most important ore mineral of quicksilver is cinnabar, the brilliant red sulfide of mercury, from which over 95 percent of the world's output of the liquid metal is obtained. Although there are 13 mineral species found in California that contain mercury as part of their chemical composition only two others, besides cinnabar occur in commercial quantities; native mercury, which is fairly common and metacinnabar, the black sulfide, which is the least common of these three ore-minerals. Cinnabar is generally massive, earthy or minutely crystalline, but good crystals are occasionally found. The color is cochineal-red often inclining to brownish red and lead-gray; the streak is scarlet. The hardness is 2 - 2.5 and the gravity is 8 - 8.2. It is distinguished from other red-colored minerals by its high specific gravity, brilliant adamantine luster and perfect cleavage.

OCCURRENCE - The principal quicksilver ore deposits of California are found in the Coast Ranges, within a northwest - southeast belt approximately 400 miles long by 75 miles wide, extending from Santa Barbara County on the south to an area about Clear Lake, 100 miles north of San Francisco. Most of these deposits occur in the fracture planes of basic igneous rocks (especially serpentines) and their associated sediments (sandstones, shales and cherts). In addition to the principal Coast Range Quicksilver belt, there are other more scattered deposits in California. In two of these, the Cuddeback and Coso mines, the ore occurs in rhyolitic rocks. Quicksilver deposits appear to be related to volcanic activity and are frequently found to be the result of hot springs and fumaroles.

PREPARATION - The ores of mercury mined in California, unlike most other metals that are won by smelting, are treated at the mines, and the liquid metal is shipped as a finished commercial product in iron flasks containing 76 lb. each. Two kinds of reducing apparatus are used: (1) In the furnace method, the ore is directly exposed to the action of the flame; the volatile products of combustion, with more or less dust, sulfur vapors and mercury, are driven out of the ore, and all pass together through the condensers. The operation is continuous. (2) In the case of retorts, the ore is heated in a closed vessel away from the flame, and only the volatile constituents that are released from the ore, chiefly mercury and sulfur, pass into the condensing apparatus. In most retorts the operation is intermittent.

QUICKSILVER (Continued)

USES - Wehrly, whose paper is listed in the bibliography, summarized mercury uses as follows: In this country about 45 percent of the total mercury consumed is used in the preparation of mercurial salts - calomel, corrosives, oxides, organic mercurials, and other chemical compounds. In this class - the chemical uses - is also placed the production of fulminate, taking normally about 6 percent; vermilion, 6 percent; acetic acid, 2½ percent; and dyestuffs, slightly over 1 percent. The total for this class is over 60 percent. Mechanical adaptations calling for a total of about 13 percent comprise meters, measuring instruments such as barometers, hydrometers, thermometers, and gages; thermostats, vacuum tubes and pumps and pressure-control instruments. Of these, meters consume the most - about 6½ percent. In the electrical field, using a little over 8 percent, are such applications as battery zincs, diffusion lamps, cells for the preparation of caustic soda and chlorine, and arc rectifiers. Batteries and lamps take about equal quantities - 2.7 percent. These uses total about 81 percent. Of the remainder, the most important use is in the preparation of hatters felt, using over 10 percent of the total. Others are gold amalgamation, about 2 percent; dental amalgams, over 2½ percent; thermostatic and plating alloys, ½ percent; and laboratory use, about 2 percent.

TESTS - Cinnabar (HgS), when carefully heated in the open tube gives sulphurous fumes and metallic mercury, which condenses in minute globules on the cold walls of the tube. In the closed tube alone the mineral gives a black sublimate of mercuric sulfide, but with dry sodium carbonate one of metallic mercury. Before the blowpipe on charcoal it is wholly volatile, but only when quite free from gangue.

MARKETS

Quicksilver, per 76 lb. flask - $180. (Quotation, April 1, 1941)

POSSIBLE BUYERS

Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, NY.
H. W. Berk & Company, Inc., Coast Chemical Division, 55 New Montgomery St., San Francisco, Calif.
The Chisos Mining Co., 52 Exchange St., Portland, Maine.
Harrigues, Stewart & Davies, Inc., 40 Rector St., New York, N. Y.
General Color Company, Avenue B. and Wright St., Newark, N. J.
Goldsmith Bros. Smelting & Refining Co., 58 E. Washington St., Chicago, Ill.
J. H. Gould & Co., 10 Pent House, Mills Bldg., San Francisco, Calif.
Haas Brothers, 63 Wall St., New York, N. Y.
Hevenor & Jehle, 326 West Madison St., Chicago, Ill.
Chas. L. Huisking & Co., Inc., 155 Varick St., New York, N. Y.
Leghorn Trading Co., Inc., 21 West St., New York, N. Y.
John F. Maher & Co., 1600 Henderson St., Houston, Texas.
Mallinckrodt Chemical Works, St. Louis, Mo.
McKesson & Robbins, Inc., 79 Cliff St., New York, N. Y.
Mefford Chemical Co., 1026 Santa Fe Ave., Los Angeles, Calif.
Merck & Co., Inc., Rahway, N. J.

QUICKSILVER (Continued)

National Zinc Co., Inc., Bartlesville, Okla.
George Newhall, Newhall Building, San Francisco, Calif.
The New York Quinine & Chemical Works, Inc., 99 North 11th St., Brooklyn, N. Y.
F. W. Pabst, la Calle de Zaragoza 24, Mexico, D. F., Mexico.
Pacific Vegetable Oil Co., 62 Townsend St., San Francisco, Calif.
Harry W. Peabody & Co., 230 California St., San Francisco, Calif.
Quicksilver Producers Association, Inc., 407 Sansome St., San Francisco, Calif.
H. H. Rosenthal Co., Inc., 25 East 26th St., New York, N. Y.
George Uhe Co., 75 Eighth Ave., New York, N. Y.
Verde Quicksilver Sales Co., 14 Wall St., New York, N. Y.
The Wood Ridge Manufacturing Div., F. W. Berk & Co., Inc., Railroad St., Wood Ridge, N. J.

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C. P. Ross: Quicksilver Deposits of the Mayacmas and Sulphur Bank Districts, California. U. S. Geol. Survey Bull. 922-L (1940).
C. P. Ross: Quicksilver Deposits of the Mount Diablo District, Contra Costa County, California. U. S. Geol. Survey Bull. 922-B (1940).
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NOTES

Specimens of quicksilver ores may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | OCTOBER - 1942 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

SILVER

By
George L. Gary, Mineral Technologist

The most common silver-bearing minerals in California are argentite, pyrargyrite, proustite, cerargyrite, and argentiferous tetrahedrite (freibergite). However, in many ore deposits, argentiferous galena is the most abundant primary ore.

PROPERTIES - Argentite (silver sulfide, Ag_2S, 87.1 percent silver) occurs massive as crusts. The only common crystal form is the cube. The luster is metallic; color, dark lead gray, dull black on exposed surface; hardness 2½; specific gravity 7.3. It is very sectile.

Silver (Ag) is characteristically in wire form, thin sheets, skeleton crystals, dendritic groups, and masses. It rarely occurs in nuggets. It is malleable and the luster is metallic. Color tin white to pale yellow but usually dull and tarnished. Hardness 2½, specific gravity 10.5.

Pyrargyrite (silver sulfantimonite, Ag_3SbS_3, 59.9 percent silver) is also known as "dark ruby silver" ore and often occurs in small, well defined, prismatic or hexagonal crystals. The luster is metallic-adamantine, streak purple-red, color dark red to black; hardness 2½; specific gravity 5.8.

Proustite (silver sulfarsenite, Ag_3AsS_3, 65.4 percent silver) is sometimes called "ruby silver" ore. It occurs massive, incrusting, disseminated and in attached crystals. The luster is adamantine, color red on fresh surface but darkens on exposure to light, streak scarlet, cleavage imperfect, hardness 2 to 2½, specific gravity 5.6.

Tetrahedrite (copper sulfantimonite, $3Cu_2S.Sb_2S_3$ when pure. Argentiferous tetrahedrite or freibergite is the most common form in California. The silver content is variable). Tetrahedrite occurs in masses and crystals. The luster is metallic, color dark iron-gray, hardness 3½, specific gravity 4.7.

Cerargyrite (silver chloride AgCl, 75.3 percent silver) is known as "horn silver" and usually occurs in thin crusts or seams but small cubic crystals are also found. The luster is waxy to adamantine; color gray, greenish, often with a tinge of violet. The mineral darkens on exposure to light. It is very sectile. The hardness is 2, specific gravity 5.5.

OCCURRENCE - Silver has been produced from 41 counties in the State, the most important of which are Amador, Butte, Calaveras, El Dorado, Inyo, Kern, Mariposa, Mono, Napa, Nevada, Orange, Placer, Plumas, Riverside, San Bernardino, Shasta, and Yuba counties.

SILVER (continued)

Silver generally occurs as an alloy with gold (electrum - a gold-silver sulfide, of the base metals. Its most common occurrence in the lead-silver districts is with galena (PbS).

The Cerro Gordo district in Inyo County was the most productive in California. The orebodies were lenticular masses of argentiferous galena and cerusite enclosed in limestone. The silver ore is now apparently exhausted.

The argentiferous lead ores of the Darwin mining district, Inyo County, grade from contact metamorphic deposits to fissure vein deposits and are enclosed in lime silicate strata. Apparently the metallic minerals originated from deep seated magmatic sources.

Most of the silver from the Ophir district, Placer County, was derived from electrum. The ore occurs in a series of quartz veins of northwest trend which dip to the south west. The enclosing rock is granddiorite.

The gold and silver minerals of the Mojave district occur in a series of north and northwest trending quartz veins which occupy fault fissures of moderate displacement. The silver occurs mainly as cerargyrite above the water level, changing in depth to argentite.

The silver-lead-copper ores of the Blind Spring Hill District, Mono County, occur in lenses in a system of parallel, north south trending veins that have filled fault fissures in an intrusive igneous rock, varying in composition from granite to a quartz diorite. The silver is derived mainly from the secondary mineral stromeyerite which is associated with tetrahedrite and galena and is found in the lower part of the oxidized zone.

The Palisade District is the only silver producing area of importance in the northern Coast Ranges. The silver sulfides of the Palisade Mine occur in two steeply dipping, quartz fissure veins which strike N 6° E.

Silver is a by-product of the gold mines of the Grass Valley-Nevada City district.

The Randsburg district in Kern and San Bernardino counties is an important gold, silver and tungsten producing area. Most of the silver comes from San Bernardino County, not only from the Randsburg District, but also from two deposits in the Newberry Quadrangle, one in the Calico Mountains and the other in the Lava Bed District.

PREPARATION - The bulk of the world's silver is produced by refining base bullion, although some is produced by cyanidation, amalgamation, and the refining of anode mud from copper electrolysis.

Base bullion is refined by the Parkes process, the Pattinson process, and by cupellation.

The Parkes process is described in the paper on gold of the Commercial Minerals of California (Series 1941) published by the State Division of Mines. In the process, silver and gold are collected in zinc from molten lead. The zinc crust is then refined.

The Pattinson process has been replaced by the Parkes process to a large extent. The theory of the process is somewhat complicated but is essentially as follows: if a molten lead-silver alloy is carefully cooled, the silver concentrates in the liquid. When seven-eighths of the alloy has frozen, the remaining liquid is decanted. Thus the lead can be separated into high silver and low silver fractions. By repeated melting a rich bullion can be obtained containing 700 to 800 ounces of silver per ton.

STUDIES (cont'd from p. 136)

Silver and gold may be recovered from lead by cupellation if only small amounts of impurities are present. The lead-bullion is melted in a non-absorbent cupel in an oxidizing atmosphere which converts it to lead oxide or litharge (PhO). The litharge is drained off as it is formed and after all of the lead has been oxidized, there remains a button containing gold and silver.

Silver and gold are recovered from anode mud by a number of complicated processes one of which consists of a series of oxidizing steps which eliminate the impurities in the form of a slag, leaving the gold and silver alloy in a fairly pure state.

USES - An important use of silver is for coinage purposes. It is widely used in jewelry and for plating tableware, also for mirrors and in dentistry. Silver has been suggested as a partial substitute for tin in certain solders to release the tin for defense purposes. It is an excellent conductor of electricity and is used to some extent by the electrical industries. Silver salts are valuable in medicine and photography.

TESTS - With soda on charcoal in a reducing flame, silver minerals yield malleable metallic globules of silver.

On the addition of HCl, nitric acid solutions of silver minerals give a white curdy precipitate (silver chloride) which changes to violet on exposure to light and is soluble in ammonia hydroxide (NH_4OH).

MARKETS - The act of Congress approved July 6, 1939, fixed the price of domestic silver mined after July 1, 1939, at $0.711 per ounce. The price through 1938 to June 30, 1939, was $o.6464 per ounce. Foreign silver continued at 44 3/4¢. and the Treasury's buying basis held at 35¢. (Quotations as of October 1, 1942).

POSSIBLE BUYERS - The Federal Government purchases most of the domestic silver through the United States Mints at San Francisco, Philadelphia, Denver, and the United States assay offices at New Orleans and Seattle.

The majority of the silver sold by producers in California is alloyed with gold although considerable amounts are recovered from base bullion. This material is sold to smelters rather than directly to the consumers of silver.

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NOTES:

1. Specimens of silver and silver minerals may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Other silver ore minerals occurring in California are stephanite (Ag_5SbS_4), polybasite $[(AgCu)_{16}Sb_2S_{11}]$, sylvanite ($AuAgTe_4$), stromeyerite $(AgCu)_2S$, embolite Ag(ClBr).

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

MARCH - 1942

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

STRONTIUM

By
George L. Gary, Mineral Technologist

PROPERTIES - Celestite, the strontium sulfate, $SrSO_4$, (SrO, 56.4%) is found in cleavable masses and as fibrous seams. Cleavage in two directions. The mineral may be colorless, white, pale blue or red. Hardness 3. Specific gravity 3.9.

Strontianite, $SrCO_3$, strontium carbonate, contains 70.1% SrO. It occurs in acicular and prismatic crystals, in columnar and fibrous masses, and may be colorless, white, yellowish, green or brown. Hardness 3½ to 4. Specific gravity 3.7.

OCCURRENCE - Celestite occurs in San Bernardino County in the Avawatz Mountains, on the southern slope of the Cady Mountains, and just north of Barstow. It also is found in Imperial and Inyo counties.

Strontianite occurs in Inyo, Plumas and San Bernardino counties as a secondary mineral derived from celestite.

PREPARATION - Strontianite and celestite are heavy enough to permit separation from their gangue by gravity concentration.

Strontium is prepared by treating strontianite with hot nitric acid (HNO_3).

Strontium hydroxide may be prepared from either celestite or strontianite in a number of ways. One method is to reduce strontianite to strontium oxide by heating the mineral with a reducing agent such as coal, charcoal, or sulphur and then dissolve the oxide in water to form strontium hydroxide.

Celestite, the strontium sulfate, is not soluble in dilute acids and must first be roasted to strontium sulfide, which is soluble, before converting it to any of the commercial strontium salts.

Metallic strontium may be obtained by electrolysis of fused strontium chloride.

State of California
Department of Natural Resources

DIVISION OF MINES

[illegible]	MINOS - Libr	Ferry Building
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MINERAL MATERIALS OF CALIFORNIA
(Series 1954)

CELESTITE

by

George L. Burt, Mineral Technologist

CHEMISTRY - Celestite, the strontium sulfate, $SrSO_4$, (90.2% SrO) is found in electrolyte and as intrusive veins. Gangue is two varieties. The mineral may be colorless, white, pale blue or red. Hardness 3. Specific gravity 3.8.

Ethiopian, SrCO$_3$, strontium carbonate, contains 70.1% SrO. It occurs in colorless and crystalline crystals, in colorless and fibrous masses, and may be colorless, white, yellowish, green or brown. Hardness 3½ to 4. Specific gravity 3.6.

OCCURRENCE - Celestite occurs in San Bernardino County in the Mojave Desert, on the southern flank of the Cady Mountains, and at north of Barstow. It also is found in Imperial and Inyo counties.

Strontianite occurs in Inyo, Placer and San Bernardino counties as a secondary mineral derived from celestite.

PREPARATION - Strontianite and celestite are heavy enough to readily separated from their gangue by gravity concentration.

Strontium is prepared by treating this strontia with hot nitric acid (HNO_3).

Strontium chromate can be prepared into either celestite or strontianite in a number of ways. One method is to reduce strontium- to chromate by treating the mineral with a reducing agent such as coal charcoal, or sulphur and then alternately wash the oxide in water to form strontium hydroxide.

Celestite, the strontium mineral, is not soluble in dilute acids and must first be reduced to strontium sulfide, which is soluble, by heating or converting it to any of the commercial strontium salts.

Strontium chromate may be obtained by chlorination of treated strontium carbonate.

USES - Strontium is used commercially mainly in the form of compounds, some of which are nitrate, hydroxide, carbonate, and chloride. Strontium nitrate is the principal constituent of red flares both for military and civilian purposes. In other forms it is used as a necessary constituent of tracer bullets and shells.

Strontium hydroxide is used in the beet sugar industry to aid in the separation of sugar from the beet-sugar molasses.

Ground celestite is used to purify caustic soda for the rayon industry. It may be substituted for ground barite as a weighting agent in oil-well drilling mud.

Strontianite is used on a small scale in Europe for desulphurizing and dephosphorizing steel, but because of the low sulphur and phosphorous content of domestic ores, it is unimportant in the United States for this purpose.

TESTS - Strontium minerals give a crimson flame, especially with HCl. Both strontianite and celestite give an alkaline reaction on moistened turmeric paper after intense heating.

The flame is not as deep red as that for lithium and if barium chloride is used with a strontium salt on platinum wire for a flame test, the crimson coloration is destroyed, whereas with a lithium salt it is intensified. If hydrochloric acid is used for the strontium flame test, the color resembles the yellowish red of the calcium but is more persistent on prolonged heating.

Strontianite is soluble in hydrochloric acid with effervescence and strontium sulfate is precipitated from dilute solutions with sulfuric acid.

Celestite is insoluble in dilute acids and must first be fused with sodium carbonate before making wet tests for strontium.

(Calcium and barium will also come down as sulfates if they are present and for this reason the flame test for strontium is more reliable than wet tests).

MARKETS - Celestite: Per ton in carload lots, 92% $SrSo_4$, finely powdered, $45. Strontianite: Per ton lump in carload lots, minimum 84% @ 86% $SrCO_3$, $55. nominal. (Quotations March 1942).

POSSIBLE BUYERS:
Foote Mineral Company, 1609 Summer St., Philadelphia, Pa.
Pan-Chemical Company, 1396 North Harvard St., Claremont, California

REFERENCES:

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Santmyers, R.M. Strontium From a Domestic Standpoint. U.S.Bureau of Mines Economic Paper No.4, 1929.

NOTES:
Specimens of strontium minerals may be seen in the museum of the California State Division of Mines, Ferry Bldg. San Francisco, California.

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley
State Mineralogist

February - 1942

Ferry Building
San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

TALC

By
George L. Gary, Mineral Technologist

PROPERTIES - Talc, a hydrous magnesium silicate, $H_2Mg_3Si_4O_{12}$, is usually foliated massive to granular and compact massive. It has perfect basal cleavage. Thin laminae and flexible but not elastic. Sectile. Greasy feel. Luster pearly on cleavage surface. Color, white, silvery white, to apple green. It also may be greenish gray to dark green, or if impure, brownish to blackish green or reddish. Hardness 1-1½. Specific gravity 2.7 - 2.8.

OCCURRENCE - Talc is an alteration product of magnesium silicates which are found associated with igneous or metamorphic rocks and for this reason talc deposits of any importance always occur in metamorphic rocks. In California, talc is often associated with serpentine or actinolite. Soapstone deposits frequently occur in basic igneous rocks.

Talc and soapstone occur in most of the counties in California, but the main production has come from Inyo and San Bernardino counties with lesser amounts having been shipped from Butte, El Dorado, and Los Angeles counties. Other small deposits have been utilized to a small extent.

The deposits near Tecopa and Zabriskie in Inyo County occur on the contact between diorite and a banded limestone, and the talc is closely associated with fibrous tremolite. The material is from 0 to 12 feet thick and is very often soft and white.

San Bernardino County deposits lie directly south of those in Inyo County and also occur on a diorite limestone contact.

PREPARATION - The milling of talc is fairly well standardized. At present it is all ground dry and separated by air. However, to avoid the danger of silicosis, wet grinding, classifying, and concentrating is being tested in various localities and it is likely that these methods will replace the dry process.

Talc has been successfully recovered by flotation.

USES - Talc is widely used as a filler for paint, rubber, and paper. The main outlet for coarse and off-color talc is in the manufacture of roofing paper.

Calcined talc, known as "lava", may be cut, machined, and threaded. After firing, the article is hard, resistant to acids and alkalies, and has a very low coefficient of expansion. Lava is used for insulators, refractories and radio parts.

The quantity of talc used in cosmetics is very small in comparison to its other uses.

The lubricating qualities of talc make it suitable for a constituent in some cup greases. It is dusted on the inside of pneumatic tires to prevent pinching of the tube and is used in other rubber articles, such as gloves, boots, and shoes, to facilitate handling and wearing.

Some of its many other uses are to coat foundry molds, bottle molds, etc; as an absorbent for drying oily leather, as a packing material for eggs and fruit, and as an abrasive in some automobile and wood polishes.

TESTS - Talc is characterized by its smooth, soapy feel but the presence of magnesium must be proved before the material can be distinguished from pyrophyllite.

MARKETS - Per ton, carload lots, f.o.b. works. Containers included unless otherwise specified.

Talc, California domestic, 1, c.l. ton $20.00
2, c.l. ton $17.00

Georgia: 98 percent through 200 mesh, gray, $6; white $8, packed in 50 lb. paper or 200 lb. burlap bags.

New Jersey: Mineral pulp, ground, $8.50 @ $10.50. Bags extra.

New York: Double air floated, short fibre, 325 mesh $12. @ $15.

Vermont: 99½ percent through 200 mesh, extra white, bulk basis, $10.00; 97 percent through 200 mesh, medium white, $9.50. Packed in paper bags, $1.25 per ton extra.

Virginia: 200 mesh, $4.75 @ $5.50; 325 mesh, $6.20 @ $7; Crude $4.

Quotations February 1942.

POSSIBLE BUYERS

American Cyanide & Chemical Corp., 60 Rockerfeller Plaza, New York, NY
Browning, E.S. & Co., 1515 Third St., San Francisco, California.
Chrystal Co. Inc., Charles B., 18 Hudson St. New York, N. Y.
Coen Companies, Inc., 711 Gibbons St., Los Angeles, California
Consolidated Minerals Co., P.O.Box 92, Long Island City, N. Y.
Industrial Minerals & Chemical Co., 6th & Gilman Sts. Berkeley, Calif.
Innes, Speiden & Co., 117 Liberty St., New York, N. Y.
International Pulp Co., 41 Park Row, New York, N. Y.
Kennedy Minerals Co. Inc., 2550 E. Olympic Blvd., Los Angeles, Calif.
King & Co. E. & F. Inc., 405 Atlantic Ave. Boston, Mass.
Los Angeles Chemical Co., 1960 Santa Fe Ave., Los Angeles, Calif.
Merck & Co. Inc., Rahway, N. J.

Pacific Coast Talc Co., 2149 Bay St., Los Angeles, California
Parsons, M. W., Imports and Plymouth Organic Laboratories Inc., 59 Beekman St., New York, N. Y.
Rosenthal Co. Inc., H.H., 25 East 26th St., New York, N. Y.
Salamon, L.A. & Bro., 216 Pearl St., New York, N. Y.
Schundler, F.E. & Co. Inc., 620 Railroad St., Joliet, Ill.
Smith Chemical & Color Co., 55 John St., Brooklyn, N. Y.
Solomon, C. Jr., 314 Battery St., San Francisco, California
Southern California Minerals Co., 320 South Mission Road, Los Angeles, California.
Starkie, Albert E., 528 No. Cuyler Ave., Oak Park, Ill.
Tamms Silica Co., 228 North LaSalle St., Chicago, Ill.
Tropical Chemical Co. of California, 2444 East 8th St., Los Angeles, California.
Western Talc Co., 1901 East Slauson Ave., Los Angeles, California
Whittaker, Clark & Daniels Inc., 260 West Broadway, New York, N. Y.
Williams, C.K. & Co., 640 North 13th St., Easton, Pa.
Wishnick-Tumpeer, Inc., 295 Madison Ave., New York, N. Y.

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Pabst, Adolf. Minerals of California. California State Division of Mines. Bulletin 113, 1938.
Ries, H. Economic Geology. John Wiley & Sons Inc., New York Seventh Edition 1937.

NOTES

1. Specimens of talc, soapstone and pyrophyllite may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco.

2. Steatite denotes the massive, compact variety of talc, whereas soapstone is composed essentially of talc but contains other minerals as impurities.

3. Pyrophyllite is a hydrous aluminum silicate ($H_2Al_2Si_4O_{12}$), which exhibits the same soapy feel as talc and is frequently mistaken for it. Pyrophyllite and talc are nearly identical in luster, color and hardness. However, pyrophyllite is really distinguished by the presence of aluminum which may be detected by heating some of the mineral with cobalt nitrate on charcoal or by wet tests.

Pyrophyllite, like talc, occurs in schists and other metamorphic rocks and in igneous rocks as a product of hydrothermal alteration.

Certain grades of pyrophyllite may be used for many of the same purposes as talc.

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | SEPTEMBER - 1942 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

TIN

By
George L. Gary, Mineral Technologist

PROPERTIES - The only important ore of tin is the oxide, cassiterite, SnO_2. It occurs in tetragonal crystals, frequently in elbow-shaped twins with a characteristic notch, giving rise to the miner's term visor tin; often in reniform or kidney shapes, structure fibrous divergent; also massive, granular or impalpable; in rolled grains. Cleavage imperfect. Fracture uneven. Brittle. Luster adamantine and crystals usually splendent. Streak white, grayish, brownish. Color brown or black; sometimes red, gray, white or yellow. The hardness is 6-7 and the specific gravity varies from 6.8 - 7.1.

OCCURRENCE - Cassiterite is widely distributed in small amounts but is produced on a commercial scale in only a few localities. It has been noted as an original constituent of igneous rocks and pegmatites, but it is more commonly to be found in veins associated with quartz, in or near granitic rocks. Tin veins usually have minerals which contain fluorine and boron, such as tourmaline, topaz, fluorite, and apatite, and the minerals of the wall rocks are commonly much altered. It is thought, therefore, that the tin veins have been formed through the agency of vapors which carried tin with boron and fluorine. Frequently associated with wolframite. Cassiterite is also found in the form of rolled pebbles in placer deposits, stream tin. Cassiterite occurs in California in Butte, Placer, Plumas, Riverside, San Bernardino, San Diego, Siskiyou and Trinity counties but not at present found in sufficient quantities to warrant mining.

PREPARATION - Roughly about three-fourths of the tin produced is derived from placer deposits formed by the weathering and accumulation of debris from granites and quartz veins. Lode mining of tin is conducted in the manner employed in the mining of all vein deposits. The vein matter must in general carry 1 to 2 percent tin to be commercial. The mining of detrital material is accomplished by panning, hydraulicking, or by dredging. The concentrate obtained carries 60 to 75 percent metallic tin and is consigned to tin smelters for reduction. The location of the smelting plants at great distances from the mines is not an important factor in the industry owing to the low ratio of the transportation charges on the concentrates to the value of the metal.

METALLURGICAL USES - The metallurgical uses of tin, which account for about 94 percent of the consumption of new metal, automatically divide themselves into two groups - as pure metal and as alloy, the former accounting for somewhat more than half, and the latter for a little less than half of the consumption. The outstanding use is in the production of tinplate, that is, mild steel sheets covered with a layer of tin as a protective coating; a small amount is used in a similar manner to put a lead-tin coating on steel in the manufacture of terne plate, and small amounts are also used in coating metals other than steel. The other main uses for the pure metal are in foil, used in wrapping foods, tobacco, et cetera, and in collapsible tubes for salves, ointments, tooth pastes, and other similar products. Solder and babbit (bearing metal) account for the bulk of the metal used in alloy form, with lesser amounts in bronze, die casting alloys, and in similar combinations.

CHEMICAL USES - Industrial uses for tin in the form of various compounds account for about 6 percent of the consumption, about one-quarter in the form of oxide, and three-quarters in other compounds, of which the chloride is the most important. The oxide is used as an opacifying agent in white glasses and enamels, and the chloride as a weighting agent in fabrics, particularly silk.

MILITARY USES - There are no specific military uses, but war demand considerably increases the consumption of tin in many of its ordinary industrial uses, particularly tin cans, solder, and bearing metal. Such uses as we find of tin in military equipment are merely adaptations of the ordinary industrial uses, applied to a product that happens to be of a military character.

TESTS - The best test is to fine-grind the sample and dissolve in dilute hydrochloric acid. Add a small piece of aluminum, or iron, to reduce the tin to the stannous condition and filter if necessary. Then add the filtrate to a solution of mercuric chloride ($HgCl_2$). A gray precipitate (mercurous chloride HgCl) will form if tin is present.

MARKETS: Tin, per lb. f. o. b. New York, 99 percent, 52.125c. (Quotations September 1942).

POSSIBLE BUYERS

Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, NY
E. I. du Pont de Nemours & Co., Inc., (The R. & H. Chemicals Department), Wilmington, Del.
Federated Metals Division, American Smelting & Refining Co., 120 Broadway, New York, N. Y.
The Harshaw Chemical Co., Cleveland, Ohio.
The O. Hommel Co., 209 Fourth Ave., Pittsburgh, Pa.
The McGean Chemical Co., 1106 Republic Bldg., Cleveland, Ohio
Metal & Thermit Corp., 120 Broadway, New York, N. Y.
National Lead Company, 111 Broadway, New York, N. Y.

TIN (continued)

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G. A. Roush. Tin. Strategic Mineral Supplies. McGraw-Hill Book Company, Inc., New York and London (1939). pp. 162-199.
Richard J. Segerstrom. Tin in California. 37th Report of the State Mineralogist (1941). pp. 531-557.
Staff of the Foreign Minerals Division, U. S. Bureau of Mines. Mineral Raw Materials. McGraw-Hill Book Company, Inc., New York and London (1927) pp. 205-211.

NOTES

1. Specimens of tin ores may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Stannite, Cu_2FeSnS_4, is a minor ore of tin.

3. Additional Buyer: Tin Processing Company, Texas City, Texas, (Federal Agency).

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | JANUARY - 1942 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

TITANIUM

By
George L. Gary, Mineral Technologist

PROPERTIES - Ilmenite (Ferrous titanate, $FeTiO_3$, iron 36.8 per cent, titanium 31.6 per cent). It occurs in tabular crystals, in flat plates without definite outline, in disseminated grains, in compact masses, and as sand. The luster is metallic to sub-metallic. Color iron-black. Streak black to brownish black. May be magnetic without heating. The hardness is 5½ to 6. Specific gravity 4.7.

Rutile (Titanium oxide, TiO_2, titanium 60 per cent. Iron is usually present). It is found as inbedded grains or crystals, as acicular inclusions, or massive. The luster is adamantine to sub-metallic. The color is red grading through brownish red to black. Streak pale brown. Specimens may be sub-translucent or transparent. Hardness 6. Specific gravity 4.2.

Sphene (Calcium titanosilicate $CaTiSiO_5$ CaO, 28.6 per cent, TiO_2 40.8 per cent. Iron is usually present in small amounts). It occurs as crystals and grains. The luster is resinous to adamantine. Color gray, brown, green, yellow, or black. It is transparent to translucent. Hardness 5 to 5½. Specific gravity 3.5.

OCCURRENCE - Ilmenite has been found in 27 counties in California principally in the beach or river sands. Los Angeles and Santa Cruz counties report the only production in the State. The Los Angeles deposits are located at Hermosa Beach and in the San Gabriel Mountains and those in Santa Cruz County are at Aptos, about 12 miles south of Santa Cruz.

The Hermosa Beach deposit extends for 2½ miles south of Clifton. The black sands contain a heavy concentrate of titaniferous iron and form a lenticular deposit ranging in thickness from 8 feet to 14 inches. The overburden is gray and white sand containing silica, olivine, epidote, garnet, and zirconium silicate.

The titaniferous ores in the San Gabriel Mountains south of Soledad Canyon, consist almost entirely of magnetite and ilmenite with little visible gangue. They are associated with rocks of the gabbro family.

The Santa Cruz deposits occur in irregular crescents 100 to 200 feet long and as much as 50 feet wide and consist of layers of black sand up to 5 or 6 inches thick separated by thicker layers of lean sand. The sand contains magnetite, martite, and ilmenite.

TITANIUM (continued)

Rutile and sphene occur in California mainly as accessory minerals in igneous rocks and are usually not of sufficient concentration to be valuable as an ore of titanium or titanium oxide.

PREPARATION - Titaniferous iron ores may be divided into two classes for ore dressing purposes. One type contains ilmenite in large enough fragments to be released from the magnetite by crushing, followed by magnetic separation and chemical treatment of the ilmenite to produce titanium oxide. The deposits of the San Gabriel Mountains, are of this type.

The other class of titaniferous iron ores includes those in which the titanium is in chemical combination with the ores or the ilmenite is too finely divided to be separated mechanically, and require direct chemical treatment.

Metallic titanium unites very readily with oxygen or nitrogen and requires special precautions for its preparation. One process (developed by W. Kroll of Niagara Falls, N. Y.) begins with $TiCl_4$ (titanium tetrachloride) which is reduced with pure magnesium in molybdenum lined crucibles in the presence of argon at about 1000° C. The powdered metal, which does not alloy with magnesium, is separated from the magnesium salts by leaching and acid treatment. It is compressed into bars and melted in a special vacuum apparatus.

USES - The greatest amount of titanium is used in the form of the oxide as a pigment in paints, rubber, plastics, and for improving the luster of rayon. It is also used in cosmetics and soap. Rutile as such is used as a coating on welding rods.

The small amount of titanium metal used is in the form of alloys such as ferrotitanium, cuprotitanium, etc., which are added to molten metals as scavengers just before casting.

Titanium in complex deoxidizing agents containing aluminum, titanium, and vanadium, serves to protect and intensify the hardening effect of vanadium in steels so that less of this more expensive vanadium can be used.

TESTS - The phosphate bead heated in the reducing flame is violet when cold if titanium is present.

Titanium minerals fused with sodium carbonates and dissolved in hydrochloric acid gives a violet color to the solution when tin is added.

A yellow to amber color results when hydrogen peroxide is added to a sulfuric acid solution containing titanium.

MARKETS - Per gross ton ilmenite, 60 percent TiO_2, f.o.b. Atlantic seaboard, $28.00 @ $30.00 according to grade and impurities. Rutile, per lb., guaranteed minimum 94 percent concentrate, 8 @ 10¢, nominal; 88 @ 90 percent $95.00 per ton, c.i.f. New York. (Quotations as of November 20, 1941).

POSSIBLE BUYERS

American Zirconium Corp., St. Helena Ave., Baltimore, Md.
Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, N. Y.
The Chemical & Pigment Co., Div. Glidden Co., 6401 St. Helena Ave., Baltimore, Md.
Du Pont de Nemours, E.I., & Co., Inc., (Krebs Pigments Department), Wilmington, Del.

TITANIUM (continued)

Ekstrand & Tholand, Inc., 441 Lexington Ave., New York, N. Y.
Foote Mineral Company, 1609 Summer St., Philadelphia, Pa.
Harshaw Chemical Co., The, Cleveland, Ohio.
Mackay, A. D., 198 Broadway, New York, N. Y.
National Titanium Co., Vernon, California.
Titanium Alloy Mfg. Co., Drawer C, Bridge Station, Niagara Falls, N.Y.
Titanium Pigments Corporation, 111 Broadway, New York, N. Y.
United Color and Pigment Co., Div. Interchemical Corp., McClellan St., Newark, N. J.
Vanderbilt Co., R. T. Inc., 230 Park Ave., New York, N. Y.
Vitro Manufacturing Co., The, Corliss Station, Pittsburgh, Pa.
Wittaker, Clark & Daniels, Inc., 260 West Broadway, New York, N. Y.
Wishnick-Tumpeer, Inc., 295 Madison Avenue, New York, N. Y.

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Singwald, Joseph T., Jr., The Titaniferous Iron Ores in the United States. Their Composition and Economic Value. U. S. Bureau of Mines Bulletin 64, 1913.
Youngman, E. P., Deposits of Titanium-Bearing Ores. (Domestic and Foreign). U.S.Bureau of Mines Information Circular 3686. Oct. 1930.
Youngman, E.P. Titanium. U.S.Bureau of Mines Information Circular 6365. October 1930.

NOTES

1. Other titanium bearing minerals of very little importance as titanium ores are brookite (an orthorhombic form of TiO_2), and bentonite (barium titanosilicate, $BaTiSi_3O_9$).

2. Specimens of ilmenite, rutile, and sphene or titanite may be seen in the museum of the State Division of Mines, Ferry Building, San Francisco, California.

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | APRIL - 1941 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

TUNGSTEN

By
George L. Gary, Mineral Technologist

PROPERTIES - The principal ores of tungsten are wolframite, scheelite, hubnerite and ferberite. Scheelite, calcium tungstate, $CaWO_4$ is the principal tungsten mineral of California; only minor occurrences of the other tungsten minerals have been found here. Scheelite occurs massive or in pyramidal crystals with a vitreous or adamantine luster. It is white, yellowish white, pale yellow, brownish, greenish and reddish in color, and gives a white streak. The hardness is 4.5 - 5; the gravity varies from 5.9 - 6.1.

OCCURRENCE - Tungsten ores are commonly found associated with igneous rocks, such as granites, acid pegmatites and acid porphyries. The deposits may be found encased in the igneous rocks or within slates or quartzites at or near the contact of igneous rocks with sedimentaries. Tungsten deposites are generally classified as to their occurrence as follows: segregation deposits, pegmatites, veins replacement, contact metamorphic, and placers. Scheelite has been produced in California principally in the Atolia district in San Bernardino and Kern counties, followed by important deposits and production in the Tungsten Hills, near Bishop, Inyo County; and Benton Range, Mono County. Other deposits, some of which have been productive, occur in El Dorado, Fresno, Nevada, Riverside, San Diego, Siskiyou, Tulare, and Tuolumne counties.

PREPARATION - In the manufacture of tungsten steel the tungsten concentrates may be introduced directly into the steel bath but in the production of ferrotungsten, tungsten trioxide and tungsten powder several methods are employed which with the preparation of ductile tungsten and cemented tungsten carbide may be referred to in the circular on Tungsten, by William C Vanderburg which is listed in the bibliography.

USES - The principal use of tungsten is in the manufacture of tools for metal cutting. For this purpose it is employed either in certain types of steel known as high-speed tool steels (the more common one containing 18 percent tungsten, 4 percent chromium, and 1 percent vanadium) or in cemented carbides either alone or with other elements. Tungsten finds important application in electric-light and radio-tube filaments, but the quantities used are not large. Tungsten salts are used in the chemical, pigment, and tanning industries.

TESTS - The mineral is finely pulverized and heated with hydrochloric acid. If tungsten is present, a yellow powder, tungsten trioxide will be produced. Upon the addition of metallic tin or zinc the solution will turn indigo blue, the intensity of the color depending upon the amount of tungsten in the specimen tested. If the mineral is insoluble, as wolframite, fuse with sodium carbonate, and then dissolve in hydrochloric acid and test as above.

MARKETS - Tungsten ore, per unit WO_3, 65%

Wolframite, Chinese, c.i.f. New York -- in bond	$17.50-19.50
Scheelite, domestic, f.a.s., Los Angeles	$24.00 nom.
Hubnerite, domestic, f.o.b. Tucson	$23.00 nom.
Tungsten metal, per lb. in ton lots, 98% to 99%, powdered	$2.50 - 3.00

(Quotations April 1, 1941).

POSSIBLE BUYERS

Clifford L. Ach, 2309 East 8th St., Los Angeles, California.
Atkins, Kroll & Co., 260 California St., San Francisco, California.
Atolia Mining Co., Crocker Building, San Francisco, California.
Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, NY.
Bradley & Ekstrom, 320 Market St, San Francisco, California.
A. M. Capen's Sons, Inc., 50 Howard St., New York, N. Y.
Cosmo Metal Alloys Corp., 275 Front St., New York, N. Y.
Fansteel Metallurgical Corp., North Chicago, Ill.
W. R. Grace & Co., 7 Hanover Sq., New York, N. Y.
Hersch-Van Siclen, Inc., 432 Fourth Ave., New York, N. Y.
Molybdenum Corp. of America, 500 Fifth Ave., New York, N. Y.
Ore Metal & Engineering Corp., 112 Market Street, San Francisco, Calif.
Henry Rising & Co., 626 St. Paul Ave., Los Angeles, Calif.
The Ore & Chemical Corp., 80 Broad St., New York, N. Y.
Wah Chang Trading Corp., 233 Broadway, New York, N. Y.

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Dwight M. Lemmon. Tungsten Deposits in the Tungsten Hills, Inyo County, Calif. U. S. Geol. Survey Bulletin 922-Q (1941).
Dwight M. Lemmon. Tungsten Deposits of the Benton Range, Mono County, California. U. S. Geol. Survey Bulletin 922-S (1941).
Dwight M. Lemmon and John V. N. Dorr 2nd. Tungsten Deposits of the Atolia District, San Bernardino and Kern Counties, California. U. S. Geol. Survey Bulletin 922-H (1940).
Robert H. Ridgway and H. W. Davis. Molybdenum, Tungsten, and Vanadium. Minerals Yearbook (1940).
William O. Vanderburg. Tungsten. U.S. Bureau of Mines Information Circular 6821 (January 1935).
William O. Vanderburg. Mining and Milling Tungsten Ores. U.S. Bureau of Mines Information Circular 6852 (September 1935).

NOTES

1. Specimens of scheelite and other tungsten ores may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. There are other tungsten minerals found in California such as powellite and cuprotungstite but so far they are only to be considered as interesting mineralogical occurrences.

State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley State Mineralogist	MARCH - 1942	Ferry Building San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

VANADIUM

By
George L. Gary, Mineral Technologist

PROPERTIES - Vanadinite $Pb_5Cl(VO_4)_3$, a lead chlorovanadate is a source of vanadium and a minor ore of lead. It is found as sharp prismatic crystals, rounded crystals, globular forms, or as incrustations. It is ruby red, brown or yellow in color and has a resinous to adamantine luster. The streak is white or yellowish. Hardness 3. Specific gravity 6.66 to 7.10.

Carnotite, a hydrous potassium uranium vanadate, approximately $K_2O,2UO_3.V_2O_5.2H_2O$, is a source of vanadium, uranium and radium salts, which occurs as powder, in earthy masses, or as incrustations. It is canary yellow in color, rather soft, and has a specific gravity of about 4.0.

Roscoelite, $H_2K(Al,V)_3(SiO_4)_3$ a vanadium mica, is unique in having a large percentage of vanadium in place of iron. It occurs in minute scales. Pearly luster. Color, clove brown to brownish green and dark green. Hardness $2\frac{1}{2}$. Specific gravity 2.97.

OCCURRENCE - Peru is the largest single producer of vanadium in the world, followed by the United States and South West Africa.

In California vanadinite has been found in Kern and San Bernardino counties. Considerable development work was done at the San Bernardino county deposit near Goffs in an effort to expose paying quantities but without success.

Carnotite has not been reported from any locality in California. The principal commercial source of vanadium and uranium in the United States is the carnotite deposit in western Colorado and adjoining portions of Utah, which is found in loosely cemented Jurassic sandstone. Arizona also produces vanadium from the Mammouth - St.Anthony Mine, near Mammouth.

Roscoelite was first found on Granite Creek, near Coloma, El Dorado County. Later it was found in Big Red Ravine, near the old Sutter Mill in the same county, but not in commercial amounts.

PREPARATION - Vanadinite may be concentrated on tables because of its high specific gravity. Carnotite has been concentrated by air

VANADIUM (continued)

blast during the crushing process. The specific gravity of roscoelite is too low to permit its separation by gravity concentration.

The two common forms in which the concentrate is prepared for use in the manufacture of ferry-alloys are vanadium-pentoxide and ferrous-vanadate.

The finely ground vanadium concentrate is heated in a reverberatory type hearth with sodium carbonate. The vanadium is taken up by the soda slag from which it is leached and converted to vanadium pentoxide (V_2O_5).

The unroasted concentrate may be leached in lead lined vessels with sulphuric acid, and by decantation, evaporation and ignition, vanadium pentoxide is obtained.

In the separation of vanadium from carnotite, the radium and uranium are removed first, then the vanadium is precipitated from a neutral solution by ferrous sulphate as ferrous vanadate.

Vanadium may be recovered from phosphates by a patented process in which the vanadium content of a phosphoric acid solution is converted to vanadium pentoxide (V_2O_5) then extracted by means of a selective solvent.

Reduction to the metallic state and the preparation of ferro-vanadium (which contains from 30 to 40 percent vanadium) is carried on in the electric furnace or by the aluminothermic process.

USES - Vanadium is classed as one of the critical materials by the United States Army and Navy Munitions Board, and its principal use is in the manufacture of special alloy steels. It has been found necessary to increase the vanadium content of steels in which molybdenum has been substituted in part for tungsten. "Grainal" alloys which consist principally of vanadium, titanium, aluminum, and iron are claimed to increase the hardening capacity of certain structural steels.

TESTS - With borax, in the oxidizing flame, vanadates give a yellow bead when hot which changes through yellowish green to nearly colorless when cold. In the reducing flame, vanadates in a borax bead give a dirty green color which becomes a fine green upon cooling. With salt of phosphorous (sodium ammonium phosphate), material containing vanadium is yellow to amber color in the oxidizing flame and fine green after being heated in the reducing flame and allowed to cool.

Vanadium minerals are decomposed by hydrochloric acid and the solution becomes reddish brown when hydrogen peroxide is added.

MARKETS - Per lb. V_2O_5 contained, f.o.b. mines, minimum 9% concentrate, 27½¢ (Quotation February 14, 1942).

POSSIBLE BUYERS

Belmont Smelting & Refining Works, Inc., 316 Belmont Avenue, Brooklyn, N. Y.
Electro Metallurgical Company, 30 East 42nd Street, New York, N. Y.
Metallurgical Products Co., 35th and Moore Streets, Philadelphia, Pa.

POSSIBLE BUYERS (cont'd.)

Ore Metals and Engineering Co., 112 Market Street, San Francisco, California
U. S. Vanadium Corporation, 114 Sansome Street, San Francisco, California.
Vanadium Corporation of America, 420 Lexington Avenue, New York, N. Y.

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Parsons, Charles L., R.B.Moore, S.C.Lind, and O.C.Schaefer. Extraction and Recovery of Radium, Uranium and Vanadium from Carnotite. U. S. Bureau of Mines Bulletin 104, 1915.

Ries, H. Economic Geology. John Wiley & Sons, Inc., New York, N.Y. Seventh Edition. 1937.

Spur, Josiah Edward and Wormser, Felix Edgar. The Marketing of Metals and Minerals. McGraw-Hill Book Company, Inc., New York, N. Y.

Minerals Yearbook, Review of 1940, U. S. Bureau of Mines.

NOTES

1. Specimens of vanadium minerals may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. Cuprodescloizite, a variety of descloizite, $4RO,V_2O_5.H_2O$ (where R=Pb,Zn,Cu) occurs with cerussite and vanadinite at Camp Signal, San Bernardino County.

[illegible] (cont'd.)

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State of California
Department of Natural Resources

DIVISION OF MINES

Walter W. Bradley, State Mineralogist | AUGUST - 1941 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1941)

ZINC

By
George L. Gary, Mineral Technologist

PROPERTIES - The sulfide, sphalerite, ZnS, is the one common primary ore of zinc. It is usually found in cleavable masses coarse to fine granular, and can be recognized by its striking resinous luster. The color is white when pure, and green when nearly so; commonly yellow, brown to black, darkening with increase in the amount of iron present. Transparent to translucent. Streak white to yellow and brown. Hardness, 3½ - 4. Gravity, 3.9 - 4.1.

OCCURRENCE - Sphalerite, the most important ore of zinc, is an extremely common mineral, and is associated with galena, pyrite, marcasite, chalcopyrite, smithsonite, calcite and dolomite. In its occurrence and node of origin it is closely allied with galena, with which it is most commonly found. Zinc deposits are of four types: (1) residual deposits, consisting chiefly of lead minerals with which the zinc is associated; (2) vein or fissure deposits; (3) replacement deposits located particularly in limestones and dolomites; and (4) disseminated deposits confined to limestones and dolomites, in which the mineral grains are scattered through the rock. The California zinc ores of Shasta and Calaveras counties are associated with copper, while those of Inyo, Los Angeles, and San Bernardino counties are associated principally with lead-silver ores. Sphalerite, the principal ore of zinc, is very common in California and is prevalent in most of the mining regions.

PREPARATION - Metallic zinc is obtained by distillation of its roasted ores with carbon. The sulfide and carbonate, by roasting, are converted into oxide, and the silicates are calcined to remove moisture. The impure oxides, or the silicates, are mixed with fine coal and charged in tubes or vessels of clay, closed at one end and connected at the other end with a condenser. These are submitted to a gradually increasing temperature, by which the ore is reduced to metallic zinc, and, being volatile, distills, and is condensed. Metallic zinc is also obtained by electrolytic deposition.

ZINC (Continued)

USES - Metallic zinc, or spelter, as it is called, is used chiefly for galvanizing iron, as an alloy with copper in brass, and in storage and telegraph batteries. Zinc dust or zinc shavings are used to precipitate gold from its solution in the cyanide process. Large amounts of zinc are used in the pigments zinc oxide and lithopone (a mixture of barium sulfide and zinc sulfate). Zinc chloride is used as a wood preservative.

TESTS - On charcoal in the reducing flame compounds of zinc give a coating which is yellow while hot and white on cooling, and moistened by the cobalt solution and again heated becomes a fine green. Note, however, that the zinc silicate (hemimorphite) becomes blue when heated after moistening with cobalt solution. Sodium sulfide precipitates zinc sulfide in alkaline solutions.

MARKETS - Zinc - 7¼¢, St. Louis for Prime Western. Contract prices for High-Grade zinc delivered in the East and Middle West in nearly all instances command a premium of 1¢ per pound over the current market price for Prime Western. (Quotations July, 1941.)

POSSIBLE BUYERS

J. T. Baker Chemical Co., Phillipsburg, N. J.
Belmont Smelting & Refining Works, Inc., 316 Belmont Ave., Brooklyn, N. Y.
E. I. du Pont de Nemours & Co., Inc., (Electroplating Division), Wilmington, Del.
E. I. du Pont de Nemours & Co., Inc., (Grasselli Chemicals Department), Wilmington, Del.
National Lead Company, 111 Broadway, New York, N. Y.
The New Jersey Zinc Co., 160 Front St., New York, N. Y.
St. Joseph Lead Co., 250 Park Ave., New York, N. Y.
U. S. Smelting, Refining & Mining Co., Newhouse Bldg., Salt Lake City, Utah.

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Adolf Pabst. Minerals of California. Calif. State Div. of Mines, Bulletin No. 113 (1938).
E. W. Pehrson. Zinc. Minerals Yearbook 1940, pp. 127-148.

NOTES

1. Specimens of zinc ores may be seen in the museum of the California State Division of Mines, Ferry Building, San Francisco, California.

2. The carbonate, smithsonite, $ZnCO_3$, and the silicate, hemimorphite, $Zn_4Si_2O_7(OH)_2.H_2O$, are usually associated with sphalerite deposits as secondary minerals.

3. The three minerals zincite, ZnO, franklinite, $(Fe,Zn,Mn)(Fe,Mn)_2O_4$, and willemite, Zn_2SiO_4 are found in a unique deposit at Franklin, New Jersey.

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Walter W. Bradley, State Mineralogist | September - 1942 | Ferry Building, San Francisco

COMMERCIAL MINERALS OF CALIFORNIA
(Series 1942)

ZIRCONIUM

By
George L. Gary, Mineral Technologist

PROPERTIES - Zircon ($ZrSiO_4$ zirconium orthosilicate; ZrO_2 67.2 percent, SiO_2 32.8 percent) and baddeleyite (ZrO_2 Zirconium oxide ZrO_2 96.5 percent) are the commercial sources of zirconium or zirconium oxide. Brazilite is the term applied to the fibrous, botryoidal or columnar forms of baddeleyite.

Zircon is practically always found in crystals which are either embedded or occur loose in sands. It may occur in irregular grains. The luster is adamantine; color, usually brown but also red, yellow, and colorless; hardness 7½; specific gravity 4.7.

Baddeleyite occurs in tabular, monoclinic crystals with nearly perfect basal cleavage. The luster is greasy to vitreous or submetallic; color, black, brown, yellow to colorless; streak, white; hardness 6.5; specific gravity 5.5 to 6.03.

OCCURRENCE - Zircon is an accessory mineral of granitic and monzonitic rocks; it also occurs in pegmatites. It is absent from veins formed near the surface or under conditions of lessened temperature and pressure. The metal hafnium occurs in notable amounts in zirconium minerals.

Zircon occurs in considerable amounts in many placer deposits derived from the disintegration of granitic and pegmatitic rocks. The best known deposits in the U. S. are at Zirconia, near Green River, in Henderson County, North Carolina, where it occurs in the decomposed outcrops of a pegmatite dike.

Zirkite (the name applied to a commercial ore of zirconia, composed of a mixture of baddeleyite or brazilite, zircon, and a supposed new, unnamed silicate of zirconium) has been found in Brazil in the Caldas district on the border of the States of Minas Geraes and Sao Paulo. It occurs in large quantities and is probably connected with pegmatite dikes in nephelite-seyenite.

The most notable occurrence of zircon in California is in Placer County where it has been obtained in commercial quantities in the sluice boxes of the Kaufield dredge, 2 miles east of Lincoln. It is found in the following counties as an accessory mineral in acid eruptive rocks or in sands: Alamcda, Butte, Calaveras, Del Norte,

ZIRCONIUM (continued)

El Dorado, Fresno, Humboldt, Marin, Mendocino, Mono, Nevada, Plumas, Riverside, Sacramento, San Diego, San Luis Obispo, San Mateo, Santa Barbara, Santa Cruz, Shasta, Siskiyou, Trinity, Yuba.

The most important localities for gem zircons are the Mongka district, Indo-China, and Ceylon. Gen zircons also occur in Tasmania, New South Wales, and New Zealand.

USES - Zircon is used to a stedily growing extent in refractories, specialized porcelains, and heat resisting glass. The outstanding characteristics of zircon refractories are: low coefficient of expansion, high density, non-inflammability, high melting point (2570° C.), freedom from corrosion, and high mechanical strength. It is also the usual raw material for the manufacture of zirconium compounds, of which opacifiers are probably the most important, supplanting antimony and to some extent tin oxide in vitreous enamels and ceramic glazes. The use of zircon enamels is growing; they are nonpoisonous and the same opacity is obtained with 2 percent zirconium as with 6 percent antimony oxide. The oxide makes a nonpoisonous, non-discoloring white paint of permanency and good covering power, which is not affected by hydrogen sulfide, by acids or by alkalies. Zircon is used as insulation in electric heating devices, and as a coating on welding rods.

Metallic zirconium is employed as powder or ductile metal in photo-flash bulbs, radio transmitter tubes, ammunition primers and spot welding electrodes. In steel making, zirconium acts as a scavenger and deoxidizer, removing nitrogen and oxygen as well as nonmetallic inclusions. Nickel-tungsten-zirconium (cooperite) is an alloy used for high speed tools.

When transparent, zircon serves as a gem stone, rivaling the diamond in brilliance. It is colorless in some specimens, but more often of a brown and red orange color called hyacinth or jacinth. Blue zircons are produced by heat treatment. The colorless, yellowish, or smokey stones are called jargon.

PREPARATION - In the concentration of zircon from zircon or monazite sand, the sand is usually passed over magnetic separators. The monazite is removed by the strongest magnet, and ilmenite by the intermediate magnet, and the magnetite by the weakest. Zircon is recovered from the tailings by gravity concentration.

Zircon ($ZrSiO_4$) is converted to zirconium salts by (1) fusion with niter cake (sodium acid sulfate) (2) dissolving the fusion product in hot water and filtering off the free silica and other insoluble s.

TESTS - Zircon is distinguished by its crystal form and high specific gravity. It is infusible (blowpipe) but loses color. It is practically insoluble in acids. An HCL solution of a soda fusion containing zirconium turns turmeric paper orange color. This test is like that for a borate, the absence of which must be proved.

MARKETS - Zirconium alloy - 12 to 15 percent Zr, 39 to 43 percent Si, $102.50 @ $107.50 per gross ton; 35 to 40 percent Zr,

[illegible] (continued)

47 to 52 percent Si, 14 @ 16¢ per lb. Commercially pure zirconium powder, $7.00 per lb. (Quotations September 1942).

POSSIBLE BUYERS

Brazilian Minerals & Timbers Corp., 233 Broadway, New York, N.Y.
Foote Mineral Company, 1609 Summer St., Philadelphia, Pa.
Carl Marks & Co., Inc., 50 Broad St., New York, N. Y.
Mercantile Import and Export Corp., 21 East 40th St., New York, N. Y.
Montgomery Bros., 61 Fremont St., San Francisco, Calif.
Sicklick & Company, Ltd., 40 East 49th St., New York, N. Y.
C. Tennant, Sons & Co., of New York, 9 Rockerfeller Plaza, New York.
Titanium Alloy Mfg. Co., Drawer C, Bridge Station, Niagara Falls, N.Y.

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Youngman, E. P. Zirconium. U.S.Bureau of Mines Information Circular No. 6455. Part 1. General Information. June 1931.

NOTE:

Specimens of zirconium bearing minerals may be seen in the museum of the California Division of Mines, Ferry Building, San Francisco, California.

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